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A FORGOTTEN CHAPTER IN THE HISTORY OF THE CIRCULATION OF THE BLOOD *

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THE discovery of the pulmonary circulation is an interesting and debated subject. At least five¹ discoveries are reported and statues have been erected in honor of the authors.

Erasistratus of the Alexandrian School believed that the arteries and the left side of the heart were empty and served to convey the spirit of life to the body. This teaching persisted until Galen disposed of it in the second century A.D., for he showed that by pricking any artery of a living mammal blood gushed forth. He taught that most of the blood from the right side of the heart went through invisible pores in the septum to the left side of the heart. There it mixed with air to create spirit and was distributed to the body. A small portion of this blood in the left side passed back to the lung with each systole to be cleansed of its "soot." He indicated, however, that a small portion of the blood from the right side passed through the vena arteriosa and then by way of the arteria venosa reached the left side. We see, therefore, that Galen had a vague idea of the pulmonary circulation. His errors were a belief in the permeability of the septum and in the systolic reflux.

In 1553 A.D., Michael Servetus² described the pulmonary circulation and denied the permeability of the septum but upheld the Galenic theory that the blood in the arteria venosa was mixed with the inspired air and cleansed of its "soot" by expiration.

Fourteen centuries—from Galen to Servetus—pass in silence. During most of this period Arab civilization, besides preserving Greek medicine, made valuable contributions. A manuscript in our possession shows that in the thirteenth century a clear conception of the pulmonary circulation was contributed by Ibn Nafīs,³ dean of the Mansoury Hospital in Cairo, Egypt.

* A few days ago our attention was called to a valuable article by Dr. Max Meyerhof of Cairo entitled "Ibn An-Nafīs (XIIIth Cent.) and His Theory of the Lesser Circulation," published in the June issue of *Isis* (No. 65, vol. XXIII, I, pp. 100-120). We had corresponded with Dr. At-Tatawi Bey and in his answer he stated that he had turned over his data to Doctor Meyerhof and had referred our letter to the latter. In his second letter dated March 26, 1935, At-Tatawi Bey stated that he had received an answer from Doctor Meyerhof in which he gives reference to two manuscripts but no mention of any publication or article on the subject.

¹ Michael Servetus, Realdus Columbus, Carlo Ruini, Andreas Cesalpinus, François Rabelais. They all lived in the sixteenth century.

² In his *Christianismi Restitutio*.

³ Abū-l-Ḥasan Alā-ūd-Dīn Ali ibn Abi-l-Ḥazm (known as Ibn Nafīs). Brockelmann calls him Abu-el-Harm. The *z* and *r*, in Arabic, look very much alike with the exception that the *z* has a dot over it. Evidently Brockelmann overlooked the dot over his *r*.

Ibn Nafīs studied medicine in Damascus. The famous biographer and bibliographer, Ūsaibī'ā,⁴ was his contemporary. They both studied under the same teacher⁵ in Damascus and worked together in the Mansoury Hospital of Cairo, and yet the latter made no mention of the former in his biography. Ūsaibī'ā left Cairo and came to Sālkhād—from the fleshpots of Egypt to the border of the Syrian desert. We wonder if Ibn Nafīs was responsible for that departure and whether the omission was intentional. It is unfortunate that Ūsaibī'ā has failed to give us what would have been valuable first-hand information about one of the brilliant characters of the thirteenth century. However, we are not left totally in the dark for several other biographers⁶ have given us a fairly complete record of the life and work of Ibn Nafīs.

Ibn Nafīs is portrayed to us as one of the greatest physicians of his age, equal to Avicenna and even surpassing the latter in treatment. Besides medicine, he excelled in language, philosophy, Moslem canon law and traditions. He was a free thinker and one of the chief exponents of unitarianism. Unlike most of his predecessors he was a keen observer and a careful recorder of facts. His love for truth and his logical mind made him refuse to follow accepted authority blindly. He was a voluminous writer, writing fully and intelligently from memory without reference to any book. He wrote at least

Several letters of the Arabic alphabet have no equivalent in any of the European alphabets. Hence in translating Arabic manuscripts into any European language, certain proper nouns cannot be properly spelled to convey the exact Arabic pronunciation. Several systems have been adopted empirically—mostly by Orientalists—to overcome this difficulty, but none of these have been found satisfactory, as the same word may be pronounced differently by a Britisher, a Frenchman, an American, a German, or an Italian.

We must also bear in mind that the same word may be pronounced differently in the various Arabic speaking countries, and even in different sections of the same country. An American living and studying in Syria may pronounce the same word differently from one living in Egypt, Mesopotamia or Arabia.

In this article we have used the spelling that would convey to an English speaking reader the most nearly correct pronunciation.

⁴ Mūwaffāq-ūd-Dīn Aḥmad Ibn-il-Qasīm Ibn Abi Ūsaibī'a, the author of Ūyūn-ül-Anbā fi Tabāqāt-il-Atibbā, which contains, beside a brief history of Greek medicine, a complete biography of over 400 Arab physicians.

⁵ Mūhāth'thāb-ūd-Dīn Ad-Dakhlwār.

⁶ As-Safadi (695-764 A.H.), the first volume of whose book is already printed in Germany, and Moḥammad ūl-Baqir in his Rowdāt ūl-Jānnāt, have both given us excellent records of Ibn Nafīs. Five other biographers: Ibn-us-Sabki, Tabāqāt-us-Sabki; Tash Kubri Zadā, Mūtah-ūs-Sa'adāh; Siyouti, Hosn-ul-Mohathara; Al-Hanbali, Sha'tharat-ūth-Thāhab; Hajji Khalifā, Kashf-üz-Zūnūn, have also given us portraits of him.

⁷ The following is a list of his known medical books:

(1) Ash-Shāmil, an encyclopedia of medicine which would have exceeded 300 volumes if it had been completed. He wrote only 80 volumes, most of which have been lost, only a few fragments being found in the Bodleian Library (Nos. 536-539).

(2) Al-Mūhath'thab f-il-Kuḥl, a treatise on eye diseases.

(3) Al-Mūkhtār min-al-Agthi'ya, a book on diet.

(4) Sharḥ Fūsūl Abicrāt, a commentary on the Aphorisms of Hippocrates.

(5) Sharḥ Taqdimat-ül-Ma'rifā, a commentary on the Prognostica of Hippocrates.

(6) Sharḥ Masā'il Ḥunein Ibn Ishāq, a commentary on the Questionary of Hunein Ibn Ishāq.

ten books⁷ on various medical subjects and a book entitled the "Perfect Man."⁸ This latter expounds the author's unitarian belief and teachings, such as that for which Servetus suffered martyrdom. There is a striking parallelism in the fact that both described the pulmonary circulation in the course of a theologic discussion and made the same mistakes in practically the same phraseology.

In the manuscript in our possession⁹—Commentary on the Anatomy of the Canon of Avicenna—Ibn Nafīs clearly and repeatedly¹⁰ describes the pulmonary circulation. The following are literal translations of some of the passages in which he describes it.¹¹ ". . . Our purpose now is to set forth what we have been able to find of the discussions of the Sheikh, the Rais, Abi Ali al-Husein Ibn Abdallah Ibn Sina, on anatomy in his Canon, and that by collecting what he wrote in the first book of the Canon and the third book of the same, and so arrange properly all that he wrote on anatomy. What has deterred us from engaging in dissection is the authority of the law and our inherent compassion. So we see fit to depend, for the description of the internal organs, on the words of those who have preceded us—of those engaging in dissection—especially the honorable Galen, as his books are the best books that have come down to us on this subject. . . . We have relied chiefly . . . on his sayings, except in a few details which we thought might be mistakes of copyists or the fact that his description had not been given after a thorough observation. In describing the use of these organs we have depended on true observation and honest study, regardless of whether or not these fit the theories of those

(7) Sharḥ-ül-Hidayā f-it-Tıbb, a commentary on Avicenna's Hidayā.

(8) Al-Mūjaz, a compendium on Avicenna's Canon.

(9) Sharḥ Qanūn Ibn Sīna, a commentary on Avicenna's Canon.

(10) Sharḥ Tashriḥ-il-Qanūn, a commentary on the Anatomy of the Canon.

⁸ Risālat Fadīl ibn Nāṭiq (The Epistle of Fadīl Ibn Nāṭiq) on Ar-Ragul-ül-Kāmil (The Perfect Man).

⁹ This book has been mentioned by most of the Arab bibliographers. Brockelmann gives reference to four copies: Berlin No. 6272, Paris No. 2939, Bodleian II.178, and Escorial I.267.

We know of two other copies—one in the Zāhiri'yā Library, Damascus (No. 20), and the other in the private library of one of us obtained by purchase from Persia. We have had the opportunity to study and compare these two manuscripts and compare them with the Paris manuscript No. 2939. These three manuscripts are practically identical.

¹⁰ This is repeated at least five times—in his description of the pulmonary vessels, of the heart, of the lung, of the portal circulation and liver, and of the brain.

Our attention was first called to this by Sarton. In his Introduction to the History of Science he credits Doctor Muhhy-id-Din At-Tatāwy of Cairo, as being the first to call attention to Ibn Nafīs's description of the pulmonary circulation. From personal communication with Doctor At-Tatawy we have learned that he made a translation into German from the Berlin copy and that only five typewritten copies were made. He also stated that he has turned over all his data to Doctor Meyerhof of Alexandria.

¹¹ In translating these passages we tried very hard to give as literal a translation of the original as possible—sometimes at the expense of good English. A literal translation of Arabic books is always difficult as a whole chapter is one continuous sentence. The photostatic reproductions are taken from our manuscript and they have been carefully checked with photostatic reproductions from the Damascus and the Paris copies.

who have preceded us. . . . We see fit, before starting the discussion of anatomy, to write a preface that will help us to understand this science. The preface contains five discussions. The first is on the difference that animals show regarding their organs. . . .”

In describing the pulmonary vessels and their structure Ibn Nafīs disagrees with Galen and his predecessors as to the cause of the difference in structure between these vessels and the vessels in the other parts of the body. “. . . And we say, and God is the All-Knowing, whereas, one of the functions of the heart is the creation of the spirit from very thin blood strongly miscible with air, and air, so it is necessary to make, in the heart, very thin blood to make possible the creation of the spirit from that mixture. The place where the spirit is created is in the left cavity of the two cavities of the heart. Therefore, it is necessary, in the heart of man and his like—of those who have lungs—to have another cavity where the blood is thinned to become fit for mixing with the air. For if the air is mixed with the blood while it is still thick, it would not make a homogeneous mixture. This cavity (where the blood is thinned) is the right cavity of the two cavities of the heart. If the blood is thinned in this cavity it must of necessity pass to the left cavity where the spirit is created. *But between these two cavities there is no passage as that part of the heart is closed and has no apparent openings as some believed and no non-apparent opening fit for the passage of this blood as Galen believed.* The pores of the heart there are obliterated and its body is thick, and there is no doubt that the blood, when thinned, *passes in the vena arteriosa to the lung to permeate its substance and mingle with the air, its thinned part purified; and then passes in the arteria venosa to reach the left cavity of the two cavities of the heart; having mixed with the air and become fit for the creation of the spirit.* What is left of this mixture, less attenuated, the lung uses for its own nourishment. This is the reason why the vena arteriosa is made of thick walls and of two coats, so that what passes through its pores be very thin, and the arteria venosa thin and of one coat.”

In describing the anatomy of the lung Ibn Nafīs states: “The lung is composed of parts one of which is the bronchi, the second the branches of the arteria venosa and the third the branches of the vena arteriosa, and all of these are connected by loose porous flesh. . . . *The need of the lung for the vena arteriosa is to transport to it the blood that has been thinned and warmed in the heart, so that what seeps through the pores of the branches of this vessel into the alveoli of the lung may mix with what there is of air therein and combine with it, the resultant composite becoming fit to be spirit when this mixing takes place in the left cavity of the heart. The mixture is carried to the left cavity by the arteria venosa.* What is left of that blood in the inside of the branches of the vena arteriosa and passes through its apertures to the body of the lung, would be thicker than the blood that seeps through and more watery, and fit for the nourishment of the lung. This vena arteriosa while it brings to the lung its nourishment, also brings the blood that is very thin and that is fit to become animal spirit when mixed with the air. The use of arteria

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FIG. 3.—Description of the anatomy of the lung.
FIG. 4.—Description of the anatomy of the heart.

venosa is to transmit this air that is mixed with the thinned blood to the left cavity of the two cavities of the heart to become spirit. Another use is for the passage of what is left in this cavity of that mixture which was not fit for the creation of the spirit and of what is left in it of air that is overheated and useless. Both of these must come out of the cavity to make space for what comes afterwards of air alone or of air mixed with greatly thinned blood. So this vessel carries back these things to the lung to be discharged with the returning breath (expiration)."

In describing the anatomy and function of the heart Ibn Nafīs states further: ". . . The function of the heart, as we have shown, is first, the creation of animal spirit and its distribution to the organs in order to animate them. This creation comes about by heating the blood and making it thin so that when it is mixed with what there is of air in the lung, the mixture becomes fit for the production of the animal spirit. . . . *Therefore, for the nourishment of the spirit that is in the heart, it is necessary for the blood to become attenuated in the heart and its consistency very much thinned, then pass to the lung and mix with what there is of air there and be cooked in it until it is tempered and become fit for the nourishment of the spirit, and afterwards pass to the spirit that is in the heart and mix with it and nourish it. . . .* So of necessity the heart should have one cavity to contain the blood and thin it and another cavity to contain the spirit, and from this latter cavity the spirit passes to the different organs. And of necessity the cavity which contains the blood should be near the liver where the blood is made and so must be on the right side of the heart as the liver is on the right side of the body; and the cavity which contains the spirit on the left side of the heart. . . . And his (Avicenna's) statement that the heart has three ventricles . . . is not correct as the heart has only two ventricles, one filled with blood on the right side and the other filled with the spirit on the left side, *and between these two there is absolutely no opening for if there were, the blood would pass to the place of the spirit and spoil its essence. Also dissection gives the lie to what they said, as the septum between these two cavities is much thicker than elsewhere, lest some blood or spirit pass through and get lost. . . .* Again, his (Avicenna's) statement that the blood that is in the right side is to nourish the heart is not true at all, for the nourishment to the heart is from the blood that goes through the vessels that permeate the body of the heart. . . . *The benefit of this blood (that is in the right cavity) when it is thinned and attenuated is to go up to the lung, mix with what is in the lung of air, then pass through the arteria venosa to the left cavity of the two cavities of the heart and of that mixture is created the animal spirit.*"

SUMMARY

From the above literal translation of Ibn Nafī's description of the pulmonary circulation and from a careful study of his biography and books we can draw the following summary.

(1) He advises the study of comparative anatomy as an aid to the understanding of human anatomy.

(2) On several occasions he hints that he performed dissection—which was very rare among Moslem physicians—despite the fact that he denies this in his introduction. He mentions dissection as a basis for his claim.

(3) He was not a blind follower. He has his own convictions and after careful observation and recording he states these regardless of accepted authority.

(4) He classifies man as an air-breathing animal.

(5) He uses logic where observation does not suffice.

(6) He declares that blood is aerated in the lung and gives a definite description of the alveoli.

(7) He states that the heart is nourished by its own vessels.

(8) He gives a clear and definite description of the pulmonary circulation and repeats this more than five times in the text.

(9) Three manuscripts show clearly that Ibn Nafīs, a prominent Arab physician, gave a classic description of the pulmonary circulation in the thirteenth century.

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THE SURGICAL TREATMENT OF HYPERPARATHYROIDISM *

BASED ON 30 CASES CONFIRMED BY OPERATION

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THE ablation of parathyroid tissue is based upon the assumption that increased function is producing disease. In any particular case three lines of evidence test the soundness of this assumption.

(a) The demonstration of a disturbance in calcium and phosphorus metabolism is at the present time the only certain criterion upon which a diagnosis of hyperparathyroidism may be predicated. No other physiologic function has been indisputably linked with the parathyroids. If clinical experiments are undertaken in an effort to extend the indications for parathyroid surgery on the assumption that other functions may be ascribed to these glands, these efforts should be controlled by complete studies of the calcium and phosphorus metabolism.

(b) Removal of parathyroid tissue is followed by a change of the pathologic state toward normal. Certain manifestations of the disease may be of a nonreversible order (*e.g.*, bone cysts or renal calcification) but the change in metabolism following operation is striking and unmistakable.

(c) Definite structural changes in the parathyroid glands that may be correlated with the disturbance of function are a requisite finding in every case.

The cornerstone to successful surgery of the parathyroids is a positive diagnosis. An "exploratory operation" to confirm or disprove a doubtful diagnosis has little or no place in this field. The findings of the laboratory are more exact than the dissection of the surgeon, and there is no point in the operation at which the operator may lay down his scalpel and find comfort in having disproved the diagnosis. Even the demonstration of four normal parathyroid bodies is not adequate because there remains the possibility that a small adenoma of a fifth gland lies tucked away in some inaccessible region of the mediastinum. A positive diagnosis is therefore a challenge to the skill and patience of the surgeon and when these have been exhausted in a fruitless search for an adenoma, the operator is privileged to say, "the tumor cannot be found," but not, "the tumor does not exist."

Before undertaking an operation for hyperparathyroidism, the surgeon must be convinced of the correct diagnosis either through implicit confidence in his medical colleagues, or preferably by a first hand weighing of the evidence. The clinical aspects of the disease and the metabolic disturbances that accompany it have been discussed at length in many excellent articles on

* Prepared for the Xth Congress of the International Surgical Society.

the subject; the scope of the present paper is to consider certain aspects of the surgery of the parathyroids.

PARATHYROIDS AND RENAL STONE.—Renal calculus is very often the presenting clinical manifestation of the disease.^{1,2} The recognition of this fact a few years ago has been largely responsible for the number of cases of hyperparathyroidism that comprise our series. The classic form of the disease presenting advanced skeletal changes is a rarity. As more attention is directed to early symptomatology particularly in the group of patients with renal involvement, it becomes apparent that hyperparathyroidism is not a medical curiosity but a disease of real significance and of not infrequent occurrence.

Two interesting problems have been presented by these cases of hyperparathyroidism in which renal complications have been the presenting symptom. The first arises from the reference to these cases as "hyperparathyroidism without bone disease." In point of fact, the designation should be "without bone disease demonstrable by roentgenography" until further bone biopsies have been studied in this group of patients.

The other problem is of more pressing clinical importance and will be solved only by increased experience. Given a patient with renal stone and hyperparathyroidism, which takes precedence in surgical therapeutics? The tendency at the moment is to regard the disturbance of parathyroid function as a chronic disorder of metabolism that can be handled in due time after the obvious problem of conserving kidney function has been settled. In many instances, as when a calculus is blocking a ureter, this is the correct sequence of procedures. On the other hand, many sequelae of renal surgery such as sepsis and temporary disturbance of renal function may be poorly tolerated or intensified in the face of severe hyperparathyroidism. These same sequelae of renal surgery may in turn make the proper handling of the hyperparathyroidism more difficult. The only answer that can be offered at the moment is that the urologist must consider the disease as a whole and not endanger the patient by myopic regional surgery. As a general rule the initial step in treatment will be the correction of the basic disturbance of metabolism.

Although the skeletal changes incident to hyperparathyroidism are crippling and painful, the real hazard of the disease is the damage suffered by the kidneys. Renal insufficiency or the complications of renal calculus have been the only causes of death in our cases.* Only a failure to grasp this fact can account for a revival of the treatment of hyperparathyroidism by dietary measures.³ Dietary treatment was tried in early cases of our series^{2,4} with, it is true, relief of certain symptoms and actual deposition of minerals in the bones. Two of these patients (Cases 4 and 6) died of renal complications two years and six weeks respectively following the removal of the parathyroid

* Three patients have died of the renal complications of hyperparathyroidism. Since the above statement was written one patient (Case 14) died of coronary occlusion two years after complete relief of his hyperparathyroidism by operation.

adenomata. We feel, therefore, that the treatment of hyperparathyroidism by a diet high in calcium and phosphorus is not only inadequate but positively dangerous.

THE NORMAL PARATHYROID.—The variation in size and shape of parathyroid bodies in normal individuals makes it impossible to offer anything but an approximate description of a so called “normal” gland. The typical size is 3 to 6 Mm. in length, 2 to 4 Mm. in width, and 0.5 to 2 Mm. in thickness. The average weight of a single gland in an adult is in the neighborhood of 0.030 Gm. In the gross, parathyroids are apt to be confused with small collections of fat, lymph nodes, or nodules of thyroid tissue. Parathyroid tissue tends to be softer than that of lymph nodes or thyroid but not as unorganized as fat.

Although a parathyroid body tends to conform in shape to immediately adjacent structures, an important clue to its identification lies in the fact that even in the gross a definite architecture is apparent. Lymph nodes and isolated nodules of thyroid tissue are rounded and plump. Normal parathyroids tend to be flattened, oftentimes with a sharply chiseled edge on one or more sides. Another clue to their identification is the small but definite vascular pedicle that enters at a miniature hilum. The shape as well as the characteristic brown color may be altered by a subcapsular hemorrhage which, because of the paucity of supporting stroma, follows even slight trauma.

The interpretation of the many types of cells that have been described as structural elements in normal parathyroid tissue must be left to the microscopic anatomists. It is possible that significant advances will be made in this field as additional material becomes available, that permits of the correlation of structure and function. We shall refer to four major cell types and certain transitional forms.

The *chief* or principal cell is polyhedral in shape and contains a sharply demarcated, large nucleus. The cytoplasm may be scant and is faintly acidophilic. The “*wasserhelle*” or “water-clear” cell is larger than the chief cell and shows complete vacuolization of the cytoplasm, a characteristic that may be present only as a peripheral halo in the chief cell. The nucleus is eccentrically located and hyperchromatic or even pyknotic. These cells are rare in the normal gland and are grouped in small clusters. The *pale oxyphil* cell is filled with uniformly acidophilic, finely granular cytoplasm without vacuolization. The nucleus is about the size of that of the chief cell but contains less abundant chromatin. The *dark oxyphil* cell is smaller than the pale oxyphil and contains a dark red homogeneous cytoplasm. The nucleus is small and pyknotic.

The number and distribution of these cells vary with age, and unless certain changes that occur normally with increasing age are recognized, they may be erroneously considered as pathologic. The most marked of these is the increase in pale oxyphil cells that begins at puberty. These increase in number and after 40 to 50 years of age form large islands that are sharply

circumscribed but not encapsulated. This is interpreted as an involutional change.

The stroma of the normal gland of an adult contains many large fat cells,



FIG. 1.—Longitudinal section of a normal parathyroid gland from an adult, aged 42 years, showing the paucity of supporting stroma and the proportion of fat cells to glandular elements ($\times 28$).



FIG. 3.—Longitudinal section of a parathyroid gland from an adult, aged 80 years. Circumscribed islands of pale oxyphil cells are shown. These are interpreted as an involutional change with no known clinical significance ($\times 28$).

the volume of these cells making up a very appreciable fraction of the total bulk of the gland. The replacement of fat cells by parenchymatous tissue

is a striking element in pathologic changes, and one that is easily recognized in frozen sections.

The finding of normal parathyroid bodies will always be difficult and may be impossible. The recognition of the glands when exposed should be precise and certain. There is no short cut by which the experience that leads to this precision can be achieved. Autopsy room dissections, with immediate checks by frozen sections while the visual image of the gross anatomy is fresh in the mind, are the first

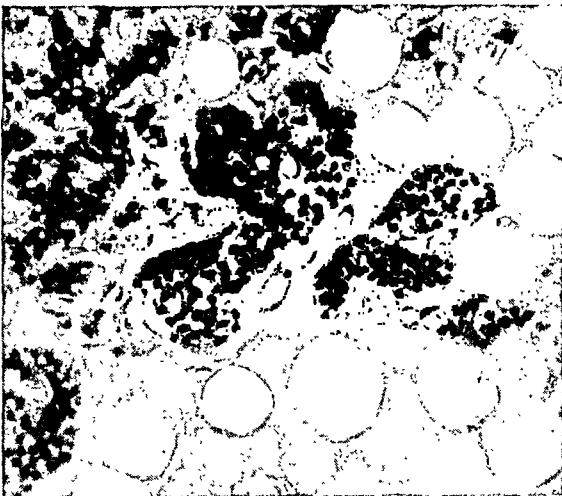


FIG. 2.—A higher magnification of a small portion of the gland shown in Fig. 1 showing normal chief cells and fat cells ($\times 350$).

steps in parathyroid surgery. In any operation the normal glands must be recognized when they are encountered and carefully preserved with their blood supply intact. *We know of no indication for the removal of a normal parathyroid body.* If doubt exists as to whether a gland is normal, biopsy with a sharp scalpel is permissible and the tissue may be immediately studied by frozen section.

Size and shape are not always obvious criteria for the recognition of pathologic changes, although usually enlargement is apparent in the gross and the characteristic chiseled edges of the normal gland are replaced by rounded contours. In Case 23 the right superior parathyroid appeared only slightly larger than normal although the other three glands were unmistakably enlarged (Fig. 10). All four showed typical "wasserhelle" cell hyperplasia of identical pattern. The size of a gland containing a small adenoma may be within the upper limits of normal variation. In Case 2 a right parathyroid body measuring 10 by 5 by 4 Mm. was removed which showed on section a well circumscribed, encapsulated adenoma making up about five-sixths of the specimen (Fig. 7). On one side there was a peripheral zone of normal parathyroid tissue. In this instance the plump, rounded contours of the gland gave the clue to the presence of the adenoma. Fortunately, the histopathology of the parathyroid bodies has been placed on a systematic basis⁵ so that operative findings can be recorded by a clean-cut definition of the microscopic pathology rather than in terms of dimensions.

PATHOLOGY.—Two major types of pathologic findings occur in cases of hyperparathyroidism: (1) adenoma of a single gland or rarely of more than one gland (neoplasia), and (2) a uniform change of all glands (hyperplasia). At the present time we are unable to predict the type that will be found in the case of any individual patient on the basis of the preoperative data. It is imperative, however, that the two forms be differentiated at the operation if effective treatment is to be carried out. Castleman and Mallory⁵ have published a detailed description of the pathologic findings in 25 cases of the Massachusetts General Hospital series. Their terminology will be followed in discussing the surgical significance of their findings. The reference to cases by number will be held identical with their designation as well as that in other publications dealing with the same patients.

HYPERPLASIA*.—The microscopic findings in all six cases described as diffuse hyperplasia are uniform and consistent. The glands are made up of large clear cells of the wasserhelle type showing a tendency to arrange themselves in acinar form. The cells vary from 10 to 40 microns in diameter,

* Generalized enlargement of the parathyroid glands has been described as secondary to longstanding renal insufficiency. It has been suggested that phosphorus retention induces a compensatory parathyroid enlargement. Bone changes may occur. As far as is known, this hyperplasia is of the chief cell type, differing from wasserhelle cell hyperplasia in microscopic section. Clinical data concerning this syndrome are fragmentary and the issue is confused by the fact that primary hyperparathyroidism may produce a secondary renal insufficiency. Surgical intervention would appear to be dangerous in case an enlargement of the parathyroids were really a compensatory mechanism.^{5,6}

averaging 15 to 20. The nuclei are all approximately the same size, averaging about 8 microns in diameter. As a rule the nuclei are located in the end of the cell that is contiguous to the stroma. This basal orientation of the nuclei produces a characteristic pattern in the low power field. Fat cells are practically absent in the stroma. No oxyphil or chief cells are found. There are no mitoses. The sections as observed with low magnification are strikingly similar to those from clear cell renal carcinomata.

A concept of parathyroid hyperplasia may be formulated by drawing a crude analogy with the thyroid gland. Case 26 showed by actual weight 11.20 Gm. of parathyroid tissue, and the weight of the residual tissue was estimated to be 0.225 Gm. This is a 95-fold increase over what may be called

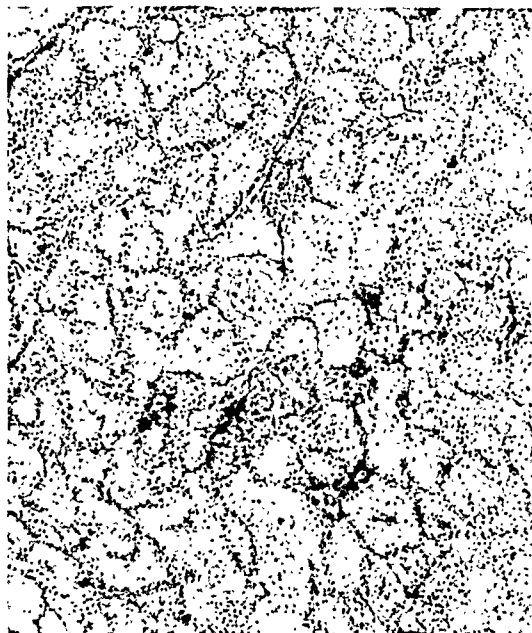


FIG. 4.—Wasserhelle cell hyperplasia. The basal orientation of the nuclei forms a characteristic pattern. There are no fat cells ($\times 78$).

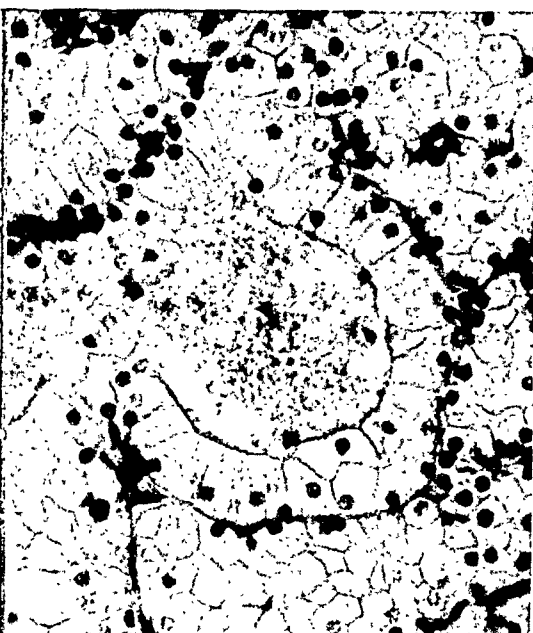


FIG. 5.—Wasserhelle cell hyperplasia. A higher magnification of a small field from the section shown in Fig. 4. Definite acinar arrangement of cells ($\times 350$).

an average normal value ($4 \times .030$ Gm.). Taking an average normal thyroid as weighing 23 Gm., hyperplasia of like magnitude would result in a goiter weighing 2,000 Gm. An exophthalmic goiter weighing 200 Gm. is an unusually large one, so the degree of hyperplasia determined by weight alone in this particular case was *ten times that found in a large exophthalmic goiter*. This computation does not take into account the fact that a considerable part of the weight of a normal parathyroid body is made up by inactive fat cells of the stroma. These are replaced by parenchymatous cells in hyperplasia. By similar computations, the largest adenoma in our series may be compared with an adenoma of the thyroid weighing 10 kilograms, or 22 pounds!

NEOPLASIA: (*Adenoma*).—Although the common type of pathologic change in hyperparathyroidism is the solitary adenoma, it will be stated again for emphasis that the pathology cannot be determined before the exposure of the glands at operation. The surgeon must therefore be prepared to adapt

his operative attack to meet the condition that is found. In four out of every five cases in our series this has been an adenoma of one gland.

In two instances among 24 cases of adenoma, tumors were found in two glands. This incidence of multiple tumors may be low as other glands were not inspected in many patients. On the other hand, the correction of the hyperparathyroidism by the operation in every instance of adenoma is presumptive evidence that other functioning tumors did not exist.

Adenomata are usually easily recognized in the gross. They are not only larger, but show a departure from the architecture of the normal gland. A



FIG. 6.—Longitudinal section of a parathyroid gland showing a small adenoma as an incidental autopsy finding. The sharply circumscribed and encapsulated adenoma encroaches upon normal gland parenchyma ($\times 28$).

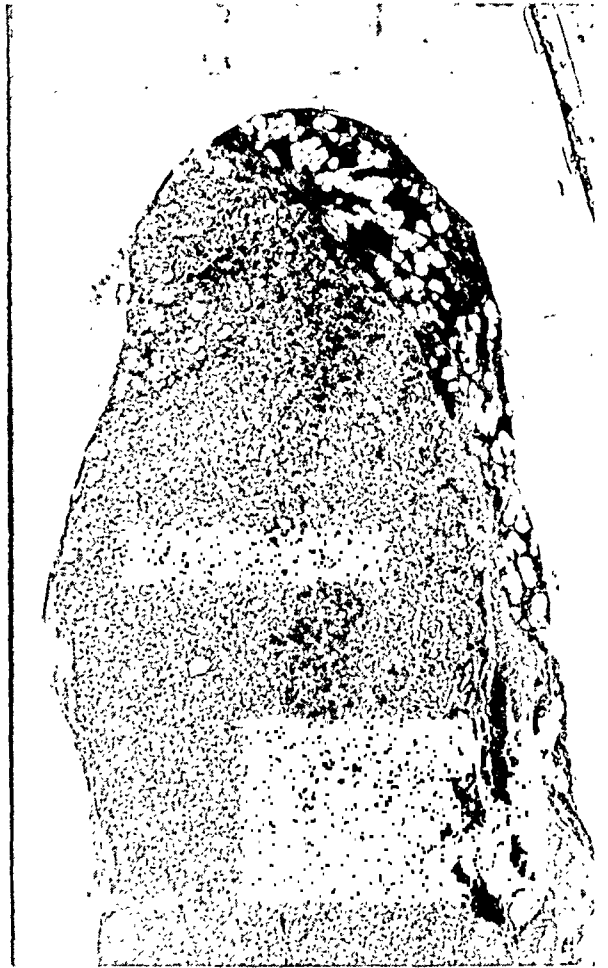


FIG. 7.—Parathyroid adenoma removed from Case 2. A narrow fringe of normal parathyroid tissue is shown at one pole of the adenoma.

frozen section is invariably made at the time of operation as the only certain means of differentiation from hyperplasia.

The size of adenomata is subject to wide variation. Castleman and Mallory have drawn a rough correlation between the size of the tumor and the degree of hypercalcemia, but other variables such as the duration of the disease are so significant that definite conclusions are unwarranted. Also the degree of hypercalcemia as observed clinically cannot be correlated with the skeletal decalcification or with the severity of clinical manifestations.

Histologically, the adenomata show a wide variation in cell type. The elaborate classification of Castleman and Mallory will not be repeated or reviewed in this paper; their conclusions, however, may be stated briefly. In the single tumors the chief cell with its transitional forms accounts for at least 90 per cent of the specimens. Pure tumors of either the oxyphil or wasserhelle type unaccompanied by chief cell forms have not been encountered in our series, although cells of either of these types may be predominant. In other words, the chief cell is the only invariable component of a tumor, and from this observation it is deduced that it is the basic fundamental cell and possibly the only proliferative form. The other cell types derived from it are interpreted as degrees of differentiation or as involution forms.

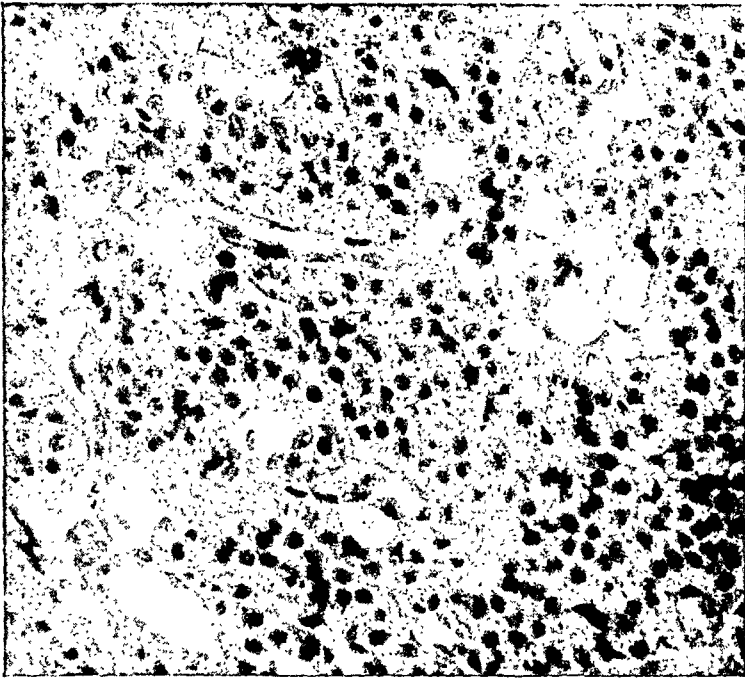


FIG. 8.—Chief cell type of adenoma from Case 9 ($\times 350$).

OPERATIVE TECHNIC.—The operation as we have previously described it is a meticulous dissection of the structures of the neck lying anterior to the prevertebral fascia. Attention is first directed to securing an adequate exposure of the thyroid gland by complete transverse section of the sternothyroid and sternohyoid muscles. Usually the omohyoid muscles are divided. The contours of the thyroid gland are studied, as a large tumor lying posteriorly may thrust one of its lobes forward. If no clue exists as to the location of the tumor, either side may be chosen for the beginning of the dissection. A traction suture is fixed in the anterolateral position of one lobe of the thyroid and the gland turned forward after ligation and section of the lateral thyroid vein. Dissection is carried posteriorly until the recurrent nerve is exposed at the point where it crosses the inferior thyroid artery. If no gross tumor has been exposed up to this point it is well to turn to the

other side and carry the dissection to the same point. From now on the conduct of the operation must be left to the resources of the individual operator. The posterior surfaces of the thyroid gland must be searched with painstaking care for normal or enlarged parathyroid bodies. When normal glands are exposed the field of search is correspondingly narrowed by exclusion. Our experience has in general confirmed the observation of Walton⁷ that tumors of the superior parathyroids may be found in the posterior mediastinum and tumors of the inferior parathyroids in the anterior mediastinum. These mediastinal tumors appear to reach this aberrant position in one of two ways, either by growth of an adenoma in a gland developmentally located in the mediastinum, or by the descent of a tumor into the mediastinum after growth in the neck. The neck should be thoroughly searched before the mediastinum is explored, as the finding of normal glands may indicate by exclusion the regions that are to be investigated first.

Splitting of the sternum to afford a direct visual approach to the anterior mediastinum is a procedure that will rarely be required. Since this was done in Case 6, we have removed two equally inaccessible tumors by digital manipulation from above. Both of these tumors were situated anterior to the great vessels at the level of the second intercostal space. They were found only by careful digital exploration, as no clue to their position was found in the neck dissection. Tumors in the posterior mediastinum in our experience have been less difficult to find than those in the anterior mediastinum as their upper end is apt to be anchored in the region of the inferior thyroid artery. When a thorough dissection has been carried out and no tumor found it is most apt to be located in the anterior mediastinum.

When a definite adenoma is disclosed early in the operation, how extensive a search should be made for a second tumor? In seeking an answer to this question we assume that a frozen section has been examined by the pathologist and generalized hyperplasia excluded. Adenomata of two parathyroid bodies have been found in two of our 30 cases of hyperparathyroidism. In one of these (Case 20) biopsies from both remaining parathyroids showed normal tissue, and in the other (Case 21) the remaining parathyroids could not be demonstrated even by resection of the lobe of the thyroid on that side. The incidence of multiple tumors in our series is therefore two in 30 or 6.6 per cent. Despite this appreciable incidence of multiple tumors, our procedure at the moment would be to stop the dissection when a definite adenoma is found, after being assured that no second tumor of large size and easy accessibility is present. If the operation is extended to rule out the presence of a second tumor, it must be carried to the extent of exposing all of the remaining parathyroids. A half-hearted search is worse than none at all because it leaves a legacy of scar tissue without achieving its purpose; namely, that of excluding a second tumor. The presence of a second adenoma will be disclosed by the postoperative trend of the blood chemistry, and if present it may be more readily found at a second operation if a relatively virginal operative field is left.

We have not personally encountered a parathyroid tumor or a normal gland lying entirely within the substance of the thyroid gland. We have observed an hyperplastic gland so deeply buried in a sulcus of the thyroid that it was found only by resection of that portion of the lobe of the thyroid gland. On careful dissection it was demonstrated that its position was outside of the true capsule of the thyroid and a small portion of it actually presented on the surface of the gland. However, normal glands as well as adenomata have been described completely buried within the substance of the thyroid, and it may be necessary to sacrifice a lobe or a portion of a lobe of that organ. Palpation of the thyroid may reveal a suspicious nodule, or the identification of normal parathyroid bodies may, by exclusion, point to the lobe or the portion of the lobe that is to be resected.

The coexistence of a nodular goiter makes the search for parathyroids very difficult. In several instances a tumor that was palpable before operation turned out to be a nodule of thyroid tissue. In only two of our cases was the parathyroid adenoma itself palpable prior to operation.

OPERATION IN HYPERPLASIA.—In a previous article⁸ we stated that "Diffuse hyperplasia of the parathyroids associated with hyperparathyroidism—in other words, a state of affairs analogous to Grave's disease of the thyroid—has not as yet been recognized as a disease entity." Since the above statement was made we have personally encountered six cases that appear to fall into that category. The first three of these cases have already been reported in full.^{9,10} In Case 15 two hyperplastic parathyroids were removed at the first operation, and a subtotal resection of a very large third gland carried out subsequently. A fourth gland could not be found. This patient shows a tendency to maintain more nearly normal calcium and phosphorus blood values than before operation, but obviously her disease has not been adequately corrected and she still has a mild hyperparathyroidism. As she is an elderly and frail individual, further surgery is not contemplated.

In Case 16 two enlarged glands were exposed on the right side and both were removed. This patient has had no further symptoms and the blood calcium level is normal. A continued low serum phosphorus suggests that mild hyperparathyroidism may be present. The actual weight of hyperplastic tissue removed from this patient was 15.6 Gm. (in terms of thyroid hyperplasia, a 3,000 Gm. goiter!). Assuming that the remaining two glands were hyperplastic, it is probable that they are small in size.

Case 17 was the first case of hyperplasia in which the true nature of the pathology was recognized at operation, and marked the beginning of the adequate surgical treatment of this condition. Four hyperplastic glands were exposed surgically; three of them and a small portion of the fourth were removed. This patient did not develop tetany and the blood levels of calcium and phosphorus have been maintained at a normal level. In all, 3.4 Gm. of hyperplastic tissue were removed from this patient.

The other three cases of generalized hyperplasia will be described in some detail as the evidence afforded by them extends our knowledge concerning

adequate surgical treatment of this form of hyperparathyroidism. These cases have already been reported briefly.^{11,12}

Case 23.—A. S., a telephone lineman, aged 41, entered the hospital February 6, 1934.¹¹ Six months previously, following attacks of left renal colic, several stones were removed from the urinary bladder by cystoscopy. He continued to have pain in the left flank and sacro-iliac region. Two months later a tonsillectomy was performed and this was followed within a week by an attack of generalized pain and tenderness throughout the entire body, particularly radiating down both legs. Recovery was slow and the dull aching pain remained localized in the left hip and sacro-iliac region. This pain was aggravated by walking and standing. He lost 35 pounds in weight. Examination was negative except for tenderness in the region of the left sacro-iliac joint and some limitation of extreme flexion and hyperextension of the spine. There was also tenderness over the bladder and over the course of the left spermatic cord. Roentgenologic examination revealed a honeycombed area of bone destruction in the central and superior portion of the left ilium. This area had the appearance of a multiloculated cystic tumor with sharply defined dense margins. The defect was approximately 6 cm. in diameter. This area was later (February 20, 1934) excised from the ilium and proved on careful pathologic examination to be an atypical chondrosarcoma. The microscopic findings in no way resembled the classic types of bone pathology known to be associated with parathyroid disease. Complete studies on the patient showed a constantly elevated serum calcium and a slightly low serum phosphorus (Table I).

TABLE I

CASE 23

Date	Calcium mg./100 cc.	Phosphorus mg./100 cc.
February 10, 1934	13.1	2.92
February 15, 1934	12.67	2.58
March 19, 1934	12.8	2.66
July 7, 1934	13.2	3.04
July 9, 1934	....	2.48
July 12, 1934	Parathyroidectomy	
July 13, 1934	10.1	2.80
July 14, 1934	9.9	2.90
July 16, 1934	9.1	3.36
July 21, 1934	11.3	3.84
July 27, 1934	10.2	3.40
August 2, 1934	11.1	3.32
October 19, 1934	11.8	3.45
April 12, 1935	9.9	3.18

Roentgenologic examination of the entire skeleton showed a mild degree of osteoporosis in the bones of the lower extremities, the pelvis and vertebrae. Roentgenograms of the urinary tract showed a calculus in the lower calyx of the left kidney. The phosphatase was 6.1 Bodansky units. Renal function was normal and the nonprotein nitrogen 35 mg. Several examinations confirmed the presence of a small amount of Bence-Jones protein in the urine. (This has been found in a few other cases of hyperparathyroidism in this series and a diagnosis of multiple myeloma considered but excluded.) The patient was discharged and returned in July, 1934, still complaining of bone and muscular pains. Further studies having confirmed the diagnosis of hyperparathyroidism, he was operated upon on July 12, 1934. The right inferior parathyroid body weighed 0.13 Gm. and measured 8 by 6 by 3 Mm. The left superior parathyroid weighed 2.18 Gm. and measured 3 by 1.7 by 0.8 cm. The left inferior parathyroid weighed 0.16 Gm. and measured

1.1 by 0.6 by 0.3 cm. These three glands were removed in their entirety. The right superior parathyroid measured 7 by 4 Mm. and a small portion was removed for biopsy. The cells throughout all specimens were found to be of the large wasserhelle type with a definite glandular arrangement. The appearance was similar to that of the other cases of hyperplasia. The patient showed no symptoms or signs of tetany. The preoperative and postoperative blood chemistry findings are recorded in Table I. There has been considerable improvement in strength and the pain and tenderness of the left hip region

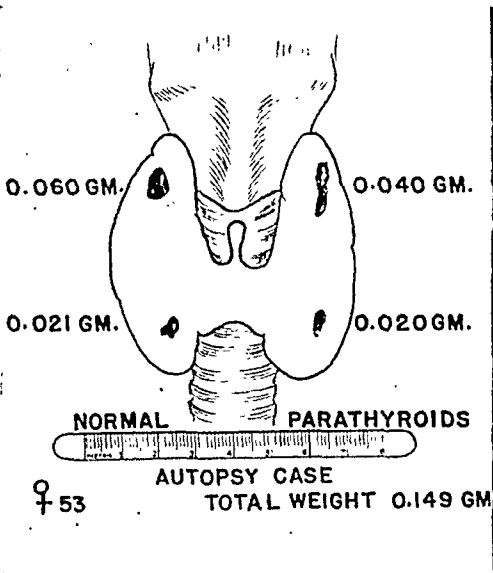


FIG. 9.—Four normal parathyroids were removed at autopsy and photographed on a diagram of the thyroid gland. The same diagram is used in Figs. 10, 11 and 12 to display surgical specimens of hyperplasia.

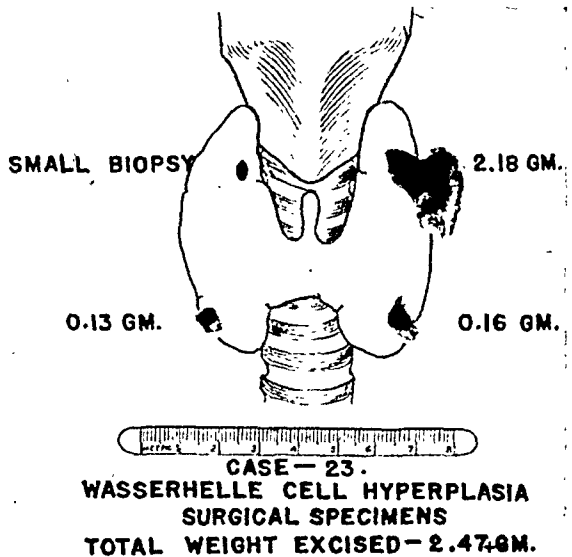


FIG. 10.—Surgical specimens from Case 23 photographed on the same diagram used in Fig. 9. The right superior gland is blocked in accordance with measurements made at operation.

has been largely relieved although the scar over the ilium is still tender. When last seen he was able to return to work.

Case 25.—W. P., a chauffeur, aged 39, had enjoyed good health until two years prior to his admission to the hospital on October 4, 1934.²² At that time he first noticed increasing thirst and generalized weakness. He began to have typical attacks of right renal colic. Roentgenologic examination confirmed the presence of a stone blocking the right ureter, which was removed October 6. Renal function tests showed normal excretion. Chemical studies that are routinely carried out on all renal stone cases showed findings consistent with hyperparathyroidism (Table II).

TABLE II

CASE 25

Date	Calcium mg./100 cc.	Phosphorus mg./100 cc.	Phosphatase
October 5, 1934	12.17	2.58	....
October 8, 1934	11.30	2.35	....
October 24, 1934	13.91	2.96	3.67
October 27, 1934		Parathyroidectomy	
October 29, 1934	9.43	1.34	3.87
November 5, 1934	9.19	3.32	....
November 21, 1934	8.82	3.20	....
December 19, 1934	8.58	3.16	....
February 27, 1935	11.63	2.96	3.68
March 13, 1935	9.74	3.24	....

Roentgenograms of the skeleton showed no variation from normal and the phosphatase was 3.6 units (4 units=normal). A careful check of the blood values confirmed the diagnosis. Operation for hyperparathyroidism was performed October 27, 1935. The thyroid gland was symmetrical and normal, and a biopsy showed normal microscopic findings. A biopsy of the tibia taken at the time of operation showed microscopically normal bone. On the right side an enlarged superior parathyroid body was easily exposed. Hyperplasia was strongly suggested by the gross appearance of this gland as it was more irregular and darker brown than the usual adenoma. A frozen section

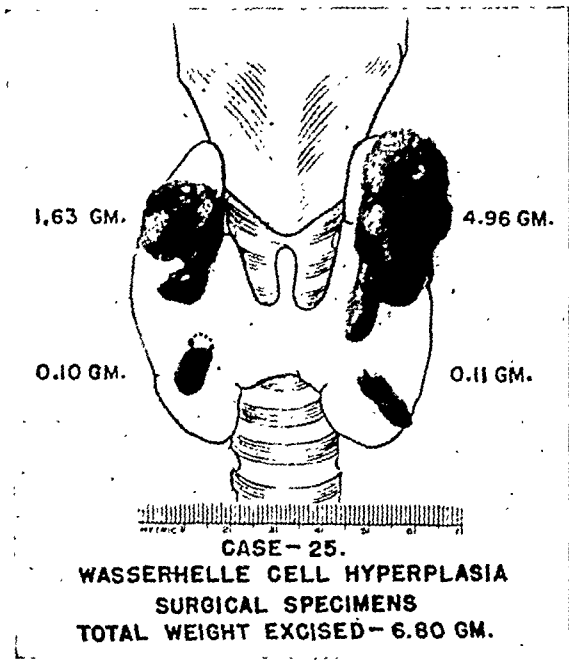


FIG. 11.—Surgical specimens from Case 25 photographed on diagram. The dotted line adjacent to the right inferior gland outlines the portion of parathyroid tissue not removed. See Table III for summary of weights.

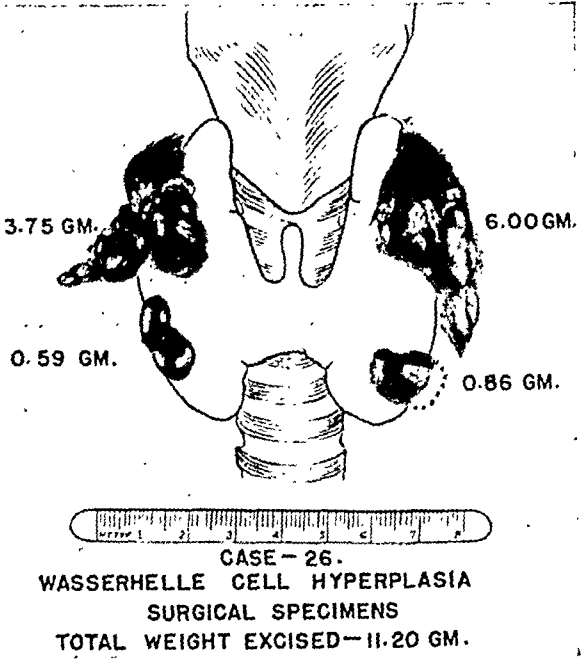


FIG. 12.—Surgical specimens from Case 26 photographed on diagram. The dotted line adjacent to the left inferior gland outlines the portion of parathyroid tissue not removed. See Table V for summary of weights.

confirmed the diagnosis of wasserhelle cell hyperplasia. Two other enlarged glands were readily found but a prolonged search was required to locate the left inferior parathyroid. It was ultimately found only by resecting the lower two-thirds of the left lobe of the thyroid. By transverse section of this part of the thyroid an enlarged parathyroid was found deeply embedded in a sulcus. In addition to this left inferior gland, both superior parathyroids were totally removed. Approximately three-fourths of the right inferior parathyroid body was then resected, leaving a modicum of tissue measuring 7 by 4 by 3.5 Mm. of estimated weight approximately 0.040 Gm. (Fig. 11). The table of weights is shown in Table III.

TABLE III

CASE 25

Weight of parathyroid tissue excised		
Left upper.....	4.96	Gm.
Right upper.....	1.63	Gm.
Left lower.....	0.11	Gm.
Right lower (subtotal).....	0.10	Gm.
<hr/>		
Total excised.....	6.80	Gm.
Weight (estimated) tissue not excised.		
Right lower.....	0.040	Gm.
Ratio remaining to amount excised $4/680$ or $1/170$		

Microscopic examination showed the cells of all the specimens to be of the large wasserhelle type, some with a tendency to acinar arrangement. These findings were taken to be characteristic of hyperplasia. The patient showed transient tetany. The course of his postoperative blood chemistry is recorded in Table II, and he has remained well to date.

Case 26.—A. T., a housewife, aged 57, was admitted on January 21, 1935.¹² Following three attacks of renal colic, she passed a urinary calculus in March, 1931. One month later her right kidney was removed elsewhere. In the summer of 1934 she experienced almost daily attacks of dull pain in the left lower back radiating at times to the groin. During the six months prior to admission she had vague aches and pains throughout her body. In the spring of 1934 her weight was approximately 98 pounds; on admission it was 83 pounds. Her appetite was poor and she complained of fatigue on exertion, increasing during the preceding six months. Roentgenograms showed generalized skeletal decalcification with several areas of diminished density in the skull that suggested multiple myeloma. Blood chemistry studies are shown in Table IV. A bone biopsy showed the changes characteristic of hyperparathyroidism. Renal function tests showed normal excretion by the remaining kidney. Blood pressure was 90/60.

TABLE IV

CASE 26

Date	Calcium mg./100 cc.	Phosphorus mg./100 cc.	Phosphatase
January 17, 1935	14.46	2.00	....
January 25, 1935	15.62	2.49	....
February 6, 1935	16.38	2.66	....
February 8, 1935	.....	2.91	4.84
February 9, 1935	Parathyroidectomy		
February 11, 1935	11.06	2.21	....
March 9, 1935	11.8	3.11	2.56
April 16, 1935	10.24	3.66	....
May 16, 1935	9.35	3.43	4.32

On February 9, 1935, an operation was performed with the diagnosis of hyperparathyroidism. All four parathyroids were exposed (Fig. 12). Their weights are recorded in Table V. Both superior glands and the right inferior were removed. Approximately three-fourths of the left inferior parathyroid was resected leaving residual tissue estimated at 0.225 mg. with a good blood supply. The pathologic diagnosis was generalized hyperplasia of wasserhelle cell type.

TABLE V

Weight of parathyroid tissue excised	
Left upper.....	6.00 Gm.
Right upper.....	3.75 Gm.
Left lower (subtotal).....	0.86 Gm.
Right lower.....	0.59 Gm.
<hr/>	
Total excised.....	11.20 Gm.
Weight (estimated) tissue not excised	
Left lower.....	.225 Gm.
Ratio remaining to amount excised .225/11.20 or 1/49.	

This patient has shown a marked improvement, gaining weight and strength. Her skeletal pains have gradually disappeared and the blood levels of calcium and phosphorus remain within normal limits. There was no tetany.

Assuming that the renal calculus episode in 1931 was a manifestation of hyperparathyroidism, the duration of generalized hyperplasia in this patient was at least four years. Certain cases of adenoma have, of course, been of much longer duration.

SECONDARY OPERATIONS.—In five instances we have been called upon to operate upon patients in whom the hyperparathyroidism had not been corrected by one or more operations in other hands. These all proved to be cases of adenoma in which the tumor had not been found at the previous operations.

TABLE VI

SECONDARY OPERATIONS

Case	Previous Operations	Position and Size of Tumor
4	(1) September 12, 1930. Two normal parathyroids and a nodule of thymus resected.	September 28, 1932. Retro-esophageal adenoma 3.5 by 2 by 1 cm.
6	(1) May 17, 1926. Normal parathyroid (right) resected. (2) June 11, 1926. Normal parathyroid (left) resected. (3) March 9, 1932 (New York City). Right lobe of thyroid resected. (4) June 27, 1932 (by authors). Left lobe of thyroid resected. (5) July 26, 1932 (by authors). Block dissection of right anterior triangle. (6) October 5, 1932 (by authors). Block dissection of left anterior triangle.	November 2, 1932. Anterior mediastinal adenoma 4 by 2.5 by 2.5 cm. Removed by splitting upper portion of sternum.
7	(1) October 19, 1931 (Worcester, Mass.). Aberrant lobe of thyroid resected. (2) May 6, 1932 (Worcester, Mass.). Major portion right lobe of thyroid and a nodule of thymus resected. Paralysis of right vocal cord.	November 15, 1932. Anterior mediastinal adenoma 3.5 by 2 by 1.5 cm.
27	(1) December 27, 1934 (Hartford, Conn.). No parathyroid tissue identified.	April 12, 1935. Adenoma posterior to right lobe of thyroid 2.6 by 1.8 by 1 cm. Subtotal resection of 3.06 Gm.
28	(1) June 27, 1934 (Madison, Wis.). "Intracapsular parathyroid tumor" removed. (Not confirmed by microscopic sections submitted.) Right lobe of thyroid removed. Two normal parathyroids identified on left. (2) December, 1934 (Iowa City, Iowa). Several pieces of tissue removed but no parathyroid tissue identified. Exploration carried "well down into upper mediastinum."	June 13, 1935. Anterior mediastinal adenoma. Subtotal resection of 11.8 Gm.

It will be seen from the table that an unusual position of the tumor is the chief cause of failure to locate it. It will also be seen that the removal of normal glands not only is without effect on the disease, but seriously complicates the situation when the tumor is found. Routine examination of the larynx is made before and after every operation, but is particularly important before a secondary procedure is contemplated. In Case 7 the right recurrent nerve had been paralyzed at one of the two previous operations, a situation

that warned one to use the most meticulous care in the dissection of the opposite side.

In a secondary operation it is our custom to define the carotid sheaths and approach the deeper regions of the neck just medial to these structures. The immediate neighborhood of the thyroid gland is disregarded if scar tissue indicates that there has been a dissection of the region. The retro-esophageal space is exposed, and also the plane between the esophagus and trachea. The search is then carried to the mediastinum, particularly its anterior portion.

POSTOPERATIVE HYPOPARATHYROIDISM.—A major problem in the surgery of hyperparathyroidism concerns the amount of tissue to be resected and the deliberate division of the operation into stages to minimize its hazards. In this matter, as in the surgery of exophthalmic goiter, the surgeon must be guided by a knowledge of the fundamental nature of the disease and a careful appraisal of the individual patient. The pathologic condition disclosed at operation is also a determinant. Of particular importance is a clear understanding of the etiology of postoperative tetany.

The danger of tetany is by no means obviated by leaving intact parathyroid tissue. In fact, severe and life-endangering tetany has been observed when a generous portion of an adenoma was left in addition to the other three presumably normal glands. Even mild postoperative tetany may be distressing to the patient, and severe tetany is not only distressing but constitutes a hazard to life. The patient suffers from paresthesias and painful muscular spasms. The dangers of laryngeal spasm are well known. The mental disturbances are apt to be alarming. A profound depression may ensue, marked by a fear of impending disaster. In one patient this led to a distinct personality change bordering on a definite psychosis. Mild cases usually clear up in a few days, but the severer forms have been prolonged for a period of two to three months. The circumstances under which a sudden reduction in the amount of parathyroid tissue may lead to profound tetany are becoming more and more apparent through experience. The problem is obviously not so simple as that of the tetania parathyropriva encountered as a complication of goiter surgery.

There is adequate basis for differentiating two types of tetany that may occur following the removal of parathyroid tissue; the *tetany of true hypoparathyroidism* and the *tetany of the recalcification period*. A third and unproven hypothesis will be briefly mentioned.

Tetany of Hypoparathyroidism.—The simplest type of tetany is found in the hypoparathyroidism that follows the ablation of parathyroid tissue to the extent that an insufficient amount remains to meet the normal requirements of the body. This form of tetany may be considered as independent of any bone disease, although if the latter is present it may be expected to alter the clinical picture especially in the immediate postoperative period. This is the type of tetany that is encountered from time to time in goiter surgery. It has occurred only once in this series of parathyroid operations.

Tetany of the Recalcification Period.—The term tetania parathyropriva

is reserved for cases in which there remains insufficient parathyroid tissue to maintain a normal level of calcium in the normal body. In hyperparathyroidism the body may be far from normal due to the depletion of the lime salts of the skeleton. Following the ablation of parathyroid tissue severe tetany then results from the abnormal demand of the bones for calcium. When this demand ceases with completed recalcification, parathyroid function is found to be normal. In case a partial resection of an adenoma is carried out to lessen the severity of this form of tetany, a mild degree of hyperparathyroidism may actually reassert itself.

This type of tetany appears similar to that encountered in rickets when a flow of calcium into a depleted skeleton is initiated by the administration of vitamin D or by sunlight.

There are two elements implicated in the production of the tetany of the recalcification period; the existing decalcification of the skeleton, and the number of osteoblasts that are ready to promote recalcification. With reference to the first element the bones may be termed "empty," while the latter indicates that the bones are also "hungry." When the disease is corrected and the flow of minerals into the bones is rapid as a result of the combined action of these two elements, the blood level of calcium falls to a tetanic level and remains there. Even a greatly increased dietary intake may be inadequate to compensate for this demand of the bones and large amounts of calcium must be provided by other routes. Only when the demand of the bones has been satisfied does the blood level of calcium return to normal.

The behavior of the phosphorus levels is also of interest. In the tetania parathyropriva of goiter surgery the phosphorus blood level rises above normal. In the tetany of the recalcification period the phosphorus tends to remain low or has even been observed to drop still further. Recovery from the period of tetany may be heralded by a rising blood phosphorus. This drop in serum phosphorus immediately following removal of parathyroid tissue has also been observed in five patients in whom no severe tetany occurred. Its full significance is not as yet apparent.

The degree of decalcification of the bones may or may not be adequately shown in the roentgenograms. An index of the osteoblastic activity is clearly afforded by the level of phosphatase in the blood serum. The enzyme phosphatase plays an important rôle in the deposition of calcium phosphate in osteogenesis. In diseases attended by active bone destruction and regeneration the amount of this enzyme in the blood is increased. Of the nine patients in this series showing preoperative phosphatase levels of more than 14 Bodansky units (four being considered as the upper limit of normal), five had severe postoperative tetany. In three of these this occurred in spite of what was considered a conservative partial resection of an adenoma.

Two of the four patients with high phosphatase levels who did not have severe tetany were operated upon after we realized the probable significance of the high serum phosphatase and a partial resection of an adenoma was done with this in view. The remaining two with high phosphatase levels and

with but transient tetany (Cases 8 and 24) both had lesions resembling Paget's disease roentgenologically, and therefore the high level may well have been due to a coincident Paget's disease.

The preoperative level of the serum calcium cannot be taken as an indication of predisposition to tetany. The serum calcium level starts to fall almost immediately after the operation and if severe tetany is to occur, the first signs become manifest within 48 hours. The level of the serum calcium at which these first signs of tetany appear varies considerably from a level well above normal values in certain instances to a level half that of normal in others.

The preoperative level of the serum phosphorus if characteristically below normal gives no indication of the tetany that may follow operation. A serum phosphorus level approaching normal values, however, is usually indicative of advanced renal damage and under these conditions severe tetany has been encountered. Tetany occurring in the presence of an already established acidosis secondary to renal insufficiency is difficult to control as it will be recalled that one of the most effective measures in the treatment of tetany is the production of acidosis.

Tetany by Inhibition of Function.—An entirely different hypothesis which may play a rôle, particularly in transient tetany, has to do with the physiologic inhibition of the activity of the normal glands by prolonged hypersecretion from an adenoma. There is some evidence that this occurs, but it is impossible to evaluate its significance without a quantitative test for circulating parathormone. The whole problem may well be elucidated when methods of determining both the calcium and phosphorus partitions of the blood are perfected and directed toward clinical problems.

RADICAL AND CONSERVATIVE OPERATIONS.—When all parathyroids are involved in generalized hyperplasia of the wasserhelle cell type a subtotal resection is indicated. The usual anatomic separation of parathyroid tissue into four units must not obscure the concept of the entire system as a single organ. To correct satisfactorily the state of hyperfunction it may be advisable to resect three glands and a liberal portion of the fourth. Estimates of the weight of residual tissue in comparison with that resected are given in the case reports.

In the case of a single adenoma the ideal procedure is a complete removal of the entire tumor. When severe tetany may be expected, as outlined above, this may be dangerous and a conservative course of partial resection should be followed. A wedge-shaped portion is removed and the gland reconstructed by fine silk stitches in its capsule. When residual tissue is left in this manner it is placed with its blood supply intact in a position where it may readily be found if a second operation proves necessary. This should be at a distance from the laryngeal nerves.

Radical and conservative measures in parathyroid surgery are therefore measured first by the extent of the subtotal resection of the entire system of

glands in hyperplasia, and secondly, by total or partial resection respectively of a single adenoma.

The catastrophe of removing all parathyroid tissue either by deliberate resection or unwitting damage to its blood supply can be avoided by careful surgery. The possibility is encountered as a real hazard in secondary operations when normal parathyroids have been actually removed or their integrity jeopardized at a previous operation. We have always done a partial resection of an adenoma under these circumstances.

We have not infrequently removed a single adenoma in its entirety without extending the dissection to demonstrate other parathyroid tissue. In Case 21, however, two adenomata were exposed and a careful search failed to reveal the other glands. Under such conditions a portion of one of them was left *in situ*. Evidence that fewer than four parathyroids may be a normal anatomic condition is always open to question as a negative finding, while evidence of the occurrence of supernumerary glands is positive and conclusive. The fact must be kept in mind, however, that even the most painstaking autopsy dissections frequently yield only two or three glands. It is possible, therefore, that the removal of even two parathyroids may be hazardous if remaining glands cannot be demonstrated. Certainly in any case of doubt, a second operation for the removal of more tissue is to be preferred to taking any risk of depriving a patient of all parathyroid tissue.

Sepsis either within the urinary tract or elsewhere appears to increase the severity of tetany and to make its treatment more difficult. Its presence therefore points the way toward less radical surgery (Fig. 13).

The indications, therefore, for conservative surgery in an effort to avoid the complications of severe postoperative tetany may be summarized as follows:

- (1) A high plasma phosphatase (14 or more Bodansky units) associated with decalcification of the skeleton. The extent of the latter may not be appreciated from roentgenologic studies.
- (2) Sepsis or general debility.
- (3) Renal impairment.
- (4) Unknown status of normal parathyroids as in a secondary operation.
- (5) Unknown status of other parathyroids when dealing with multiple adenomata.

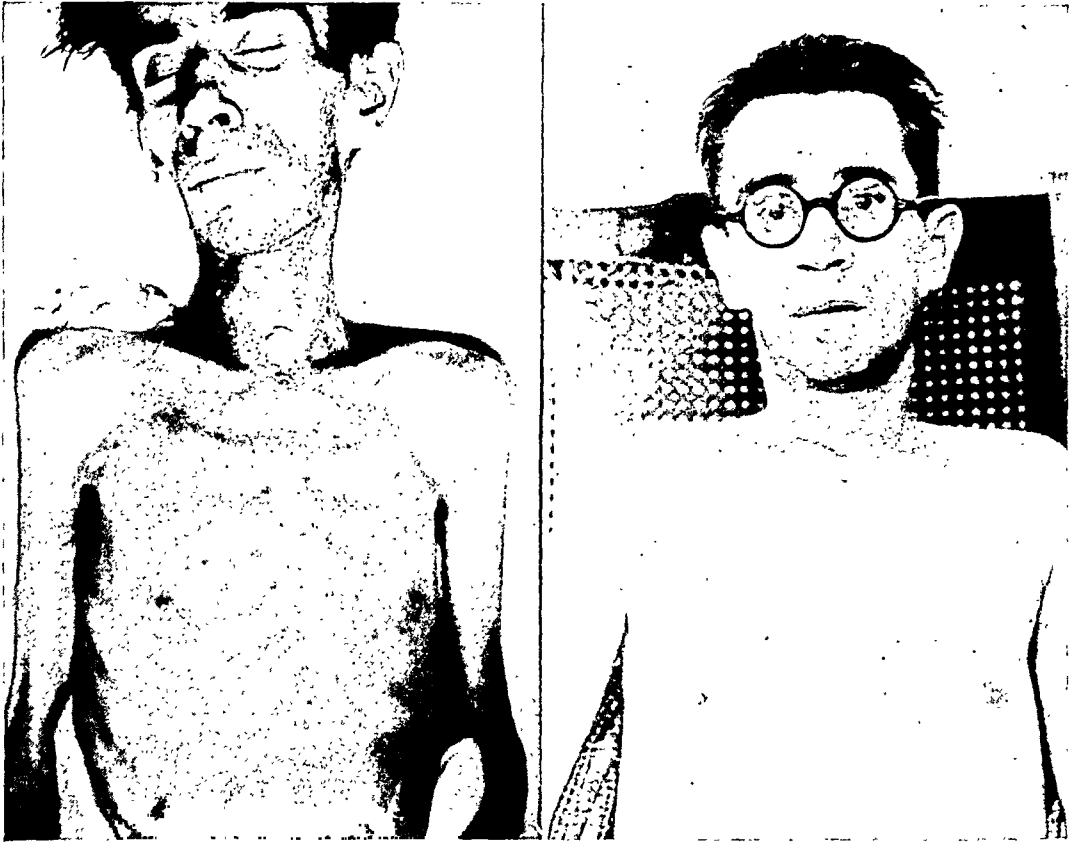
ILLUSTRATIVE CASE HISTORIES

Tetania Parathyropriva.—Only one patient in this series developed true hypoparathyroidism. Two normal parathyroids had been removed at a previous operation and in doing a partial resection of the adenoma an insufficient amount of tissue was left.

The disease in Case 4 was of the classic type with a story of weakness and bone pains of several years' duration. Skeletal disease produced multiple fractures prior to the first operation in 1930. Three kidney stones were demonstrable in the roentgenogram. During the subsequent two years she was kept under observation by Doctor Albright

and the effects of a high calcium diet studied. There was an actual deposition of lime salts in the bones with partial relief of her symptoms, but early signs of renal impairment also made their appearance during this period. This happening was an important link in the story of renal complications of hyperparathyroidism.²

This patient was the first recorded case of partial resection of a parathyroid adenoma. The tumor was found at operation in 1932. It was definitely known that two normal parathyroids had been removed in 1930. No trace could be found of a fourth gland which might well have been destroyed at the previous operation. In planning a partial resection there was no precedent upon which to estimate the secretory activity of residual adenomatous tissue. A piece of tissue twice the size of a normal gland was left. If confronted with this problem at the present time, in view of our experience with this



A

B

FIG. 13.—(A)—Case 27 on admission. Fractures of both femurs, ischiorectal abscess, decubital ulcers and advanced cachexia. Indication for partial resection of an adenoma. (B)—Six months after partial resection of a parathyroid adenoma. Gain of 42½ pounds in weight, ulcers healed, fractures uniting.

and subsequent cases, a less radical operation would be done. The amount that was left proved eventually to be just insufficient to maintain normal parathyroid function.

It is unfortunate that the records lack a determination of the phosphatase level in 1930. By all other criteria she had active bone disease at that time and it is probable that the phosphatase was elevated. In 1932, the phosphatase level was but 7.5 units, only twice the expected normal. This, it will be recalled, was after considerable recalcification of her skeleton by the high calcium diet. Two days after partial resection of the adenoma the phosphatase was only 5 units, but slightly above normal. Three days after operation mild tetany was apparent. By the thirteenth day this had developed into tetany of moderate severity with carpopedal spasm and respiratory difficulty which was promptly controlled with calcium chloride. She left the hospital less than a month after the operation with the latent hypoparathyroidism well controlled by calcium medication.

HYPERPARATHYROIDISM

Table VII records the blood levels of calcium, phosphorus, and phosphatase during the entire time she was under observation. It is of interest to note the low level reached by the serum calcium before true tetany was observed. It is also of interest that the serum phosphorus rapidly increased after operation to a high normal level. This is the characteristic finding in the tetania parathyropriva of goiter surgery—a low calcium but a high phosphorus—and should be distinguished from a high preoperative blood phosphorus which in certain cases has been associated with renal impairment. Before operation the serum phosphorus was low and although minimal signs of impaired renal function had appeared, the kidney function was apparently adequate in regard to phosphorus.

TABLE VII

CASE 4

UNCOMPLICATED HYPOPARATHYROIDISM

Date	Serum Calcium	Serum Phosphorus	Serum Phosphatase	Remarks
July 16, 1930	14.3	2.3		
July 25, 1930	12.3	3.2		
September 20, 1932	13.3	2.1	7.5	
September 26, 1932	12.5	2.2		
September 28, 1932	Partial parathyroidectomy			
September 29, 1932	9.4	3.0	5.5	
September 30, 1932	8.5	2.2	5.0	Latent tetany—Chvostek+
October 3, 1932	6.9	3.2		
October 5, 1932	5.8	4.3		
October 6, 1932	5.3	4.2		Mild tetany—paresthesias
October 7, 1932	5.8	4.2		
October 8, 1932	6.0	4.7		
October 10, 1932	5.4	4.5		Moderate tetany—spasm
October 11, 1932		5.5		Relief with calcium chloride
December 20, 1932	8.0	4.0	4.3	} Latent hypoparathyroidism Tetany occurred during upper respiratory infection
February 7, 1933	7.6	4.3	4.3	
August 14, 1933	8.0	3.2		
January 4, 1934	9.5	3.6		
January 6, 1934		Pyclothotomy		
January 18, 1934		Draining kidney		Onset of mild tetany
January 22, 1934	7.0	5.1		
March 12, 1934		Continued kidney sepsis		Mild tetany
October 27, 1934	7.3	5.0	8.4	Recurrent tetany
October 28, 1934	8.1	6.2		No tetany

During the 14 months following operation the hypoparathyroidism remained latent, controlled without signs of tetany by a high calcium intake. In the later months adding a quart of milk a day to the diet proved adequate. Following an elective operation for the removal of renal stones in January, 1934, renal sepsis developed and signs of tetany immediately reappeared. The kidney infection increased in severity and the tetany could be only partially controlled. The phosphorus now rose to higher levels and although the signs of tetany disappeared, the patient died ultimately of renal sepsis and insufficiency. At autopsy January 16, 1935, both kidneys were found destroyed by multiple large abscesses. No parathyroid tissue could be identified. A wide painstaking search failed to reveal a fourth gland. The region of the residual portion of the adenoma, marked at the time of operation by a ring of fine silver wire placed around the pedicle, was occupied by a small abscess and no recognizable parathyroid tissue. The bones of this patient had continued to recalcify until they were abnormally thick and

dense, which had been appreciated by roentgenography more than four months before death. This patient suffered from chronic hypoparathyroidism and tetany due to an insufficient amount of parathyroid tissue. The constant and prolonged need of calcium, the recrudescence of tetany with infection and the autopsy findings led to a diagnosis of hypoparathyroidism persisting from operation to death—a period of two years and three months. Tetany due to skeletal disease alone even in the most severe cases has never approached this duration.

Tetany of the Recalcification Period.—Experiences illustrated by the following case pointed the way to partial resection of an adenoma even at a primary operation when the bone disease is very active.

Case 9.—A man, aged 33, suffered for two years with bone pains and increasing generalized weakness. For three years he noted some degree of polyuria and polydipsia. The very high blood calcium of 16.8 mg., the diffuse calcification of both kidneys revealed by the roentgenograms and the relatively short duration of intense skeletal symptoms pointed toward active bone disease. This was confirmed by the very important finding of a high serum phosphatase of 26 units. A large adenoma was palpable and it was removed in its entirety by a direct operative approach with no attempt to expose the other parathyroid glands.

The operation was promptly followed by very severe tetany that was controlled with difficulty. There was a disturbing degree of mental anxiety and one alarming attack of laryngeal spasm. The signs and symptoms of tetany subsided after three months and completely disappeared within four months. There has been no recrudescence subsequently and as far as can be determined his parathyroid function is normal.

Roentgenologic evidence alone, even though it demonstrates extreme decalcification of the skeleton, does not indicate this dangerous degree of bone activity. In two instances patients have shown roentgenologic evidence of extensive disease of the skeleton but following total removal of an adenoma have exhibited no tetany. These patients have given a long history of skeletal pains associated with generalized decalcification. In both instances the serum phosphatase level was normal, indicating minimal osteoblastic activity. These bones were “empty” but not “hungry.”

Case 2.—Miss M. L., aged 55, was one of these two patients. For more than five years she had had aches and pains variously interpreted by her medical advisers as arthritis, flat feet or neurasthenia. During the two years prior to operation she had been practically bedridden. Roentgenograms of the entire skeleton showed generalized decalcification. The cortex of the bones was almost paper-thin. Trabeculae were conspicuous by their absence. The serum calcium was just above normal and the phosphorus was definitely low. The serum phosphatase was 3.2 units, a normal reading. The whole of her small adenoma was removed at operation. The serum calcium dropped to normal, the serum phosphorus level first descended slightly and then returned promptly to normal. There were neither signs nor symptoms of tetany. During the following year her skeleton slowly recalcified with rapid disappearance of her symptoms. Her case has been an outstanding clinical cure of the disease.

Two Stage Operation.—The following case illustrates the conservative handling of a patient with extensive bone disease and a high phosphatase level. It serves as an example of the proper use of partial resection of an adenoma even though a later operation was required for removal of the unexcised portion.

Case 11.—A woman, aged 53, had had skeletal symptoms for 15 years. Three years before admission she had fractured her left forearm and left tibia. Four years before entry at another hospital, a giant cell tumor was removed from her jaw. A fracture of the femur was the precipitating cause of her entering a nearby hospital when the correct diagnosis was made. Roentgenograms showed generalized decalcification of the skeleton of an extreme degree with cysts and giant cell tumors. The serum phosphatase was 16 units. At operation a large parathyroid adenoma was found on the left side weighing approximately 5.5 Gm. Five Gm. were removed and the remaining portion, the tissue around the hilum, was left in an easily accessible position anterior and medial to the left upper pole of the thyroid. Mild transient tetany followed. The serum calcium level which preoperatively was 13.0 mg. descended to 7.4 mg. by the fifth postoperative day. For another two weeks it remained in the neighborhood of 7 mg., then slowly rose until five weeks after operation it was 9.8 mg. The serum phosphorus level increased slowly from a preoperative level of 1.4 mg. to 3.0 mg. five weeks after operation. On discharge from the hospital six weeks after operation there was no evidence of calcification or callus formation at the site of fracture in the femur. A suggested interpretation is that the entire decalcified skeleton was absorbing calcium so fast that the site of fracture was unable to obtain a preferential supply of calcium for healing.

Ten weeks after operation she was readmitted for removal of the plaster spica. The serum calcium was then 11.6 mg. and the serum phosphorus 2.8 mg., indicating a persistent hyperparathyroidism. Her serum phosphatase was now but 5.3 units, a finding of great importance. Because the phosphatase level was nearly normal, it was thought safe to remove the remainder of the tumor. This was done under local anesthesia by direct approach. Seven days after operation the serum calcium was 8.5 mg., serum phosphorus 3.2 mg. There was no tetany. She was discharged on the twelfth postoperative day. A year and one-half after her second parathyroid operation she shows residual deformities from the several fractures which limit motion. Recalcification of her skeleton has been slow but her bone pains have disappeared. Except for the deformities she may be considered a clinical cure. The levels of calcium and phosphorus in her serum have remained normal. The phosphatase level is 5.2 units, still slightly above normal. It is probable that recalcification is still occurring. At the time of the first operation it was thought that a severe tetany would ensue in such a frail and debilitated patient, had the entire adenoma been removed. A partial resection with reduction of the hyperparathyroidism appeared to appease the hunger of the bones, so that when the hyperparathyroidism was finally completely corrected, a high calcium intake was sufficient to prevent any tetany.

PREOPERATIVE AND POSTOPERATIVE TREATMENT.—If there is reason for delaying the operation after the diagnosis has been established, as may occur if the exigencies of a renal complication are present, the diet is to be kept low in calcium. Although a diet rich in calcium and phosphorus might conceivably reduce the danger of postoperative tetany, the hazard of further kidney damage is too great to warrant such a program. Maintenance of an acid urine may minimize the precipitation of calcium phosphate but on the other hand tends to increase calcium excretion. It is probably best to maintain the urinary reaction just on the acid side.

Immediately after the operation the patient is given glucose solution intravenously to stimulate an adequate renal output. A diet high in calcium and low in phosphorus is immediately started, and if the signs and symptoms of tetany appear, additional calcium is given by oral and intravenous routes. If a high calcium diet had been started immediately following the operation

TABLE VIII

Case No.	Clinical Type	Preoperative Studies			Operations		Postoperative Tetany	Follow Up Status				Remarks				
		Blood Levels		Calcium Excretion	Bone Biopsy	Date		Procedure	Symptoms	Kidneys	Skele-ton		Blood Level			
		Ca.	Phos. Ptae.										Ca.	Phos. Ptae.		
1	Classic	13.7	1.9	+	+	12-10-30	Total resection single adenoma	Slight transient	5-15-35	Relieved		Cystis same Calcif. +	8.2	2.6	4.3	Clinical cure
2	Osteoporosis	10.4	3.6	+		1-14-32	Total resection single adenoma	o	5-27-33	Relieved		Calcif. +	10.8	4.3		Clinical cure
3	Nephrocalcinosis	12.3 12.1	3.6 4.7	+	+	4-9-32	Total resection single adenoma	Moderate prolonged cataracts	5-14-33	Im-proved	Unim-proved	Calcif. +	8.0	6.0		Died 10-5-33, renal insufficiency
4	Classic. Renal stones	14.2	2.3	7.5	+	9-28-32	Partial resection single adenoma	Prolonged latent tetany	12-27-34	Relieved	Unim-proved	Calcif. +	8.1	6.2		Died 1-16-35, renal infection
5	Renal stones. Osteoporosis	13.0	2.7	4.0	+	10-3-32	Total resection single adenoma	Slight, transient	10-8-32				9.3	2.5		Clinical cure but refuses follow up
6	Classic. Nephrocalcinosis. Renal stones	13.1 16.5	1.4 3.2	+	+	11-2-32	Partial resection single adenoma	Severe								studies
7	Classic	13.5	2.4	17.2	+	11-15-32	Partial resection single adenoma	Moderate, transient	5-15-35	Relieved		Calcif. +	8.2	3.3	4.9	Clinical cure
8	Classic. ? Paget's. Renal stones	14.0	1.5	18.0	+	11-30-32	Total resection single adenoma	Slight, transient	10-23-34	Relieved	Im-proved	Calcif. +	10.6	3.8	6.0	Clinical cure
9	Osteoporosis. Nephrocalcinosis	16.8	2.9	26.0	+	4-4-33	Total resection single adenoma	Severe	8-3-35	Relieved	Unim-proved	Calcif. +	10.4	2.1		Hypertension, renal calcification
10	Renal stones	14.0	2.6	4.0	+	5-24-33	Total resection single adenoma	None	5-14-35	Relieved	Im-proved		8.5	3.4	7.5	Cystostomy sinus still draining
11	Classic	13.9 11.6	1.6 2.8	16.0 5.3	+	6-24-33 11-15-33	Partial resection single adenoma Resect. residuum single adenoma	Slight, transient o	5-15-35	Im-proved Relieved		Calcif. +	8.8	2.4	5.2	Clinical cure
12	Renal stones	11.5	3.1	2.7		10-7-33	Total resection single adenoma	Slight, transient	4-15-35	Relieved	Im-proved	Normal	9.7	3.5	2.9	Nephrostenotomy in solitary kidney healed, clinical cure
13	Renal stones	15.8	2.8	4.0	Normal	10-28-33	Total resection single adenoma	Slight, transient o	5-18-35	Relieved	Normal	Normal	10.1	3.3	2.8	Clinical cure
14	Renal stones. Osteoporosis	14.5	1.9	6.5		11-20-33	Total resection single adenoma									Died 4-23-35, coronary occlusion

HYPERPARATHYROIDISM

15	Renal stones	15.0	2.2	7.3	12-19-33	Total excision two hyperplas- tic glands	0					1-21-35, cholecysto- tomy
		14.0	2.3	5.7	2-28-34	Subtotal resec- tion third hyper- plastic gland	0	7-10-35	Unim- proved	11.8	2.6	6.0
16	Renal stones	16.7	1.7		2-16-34	Total excision two hyperplas- tic glands	0	7-14-35	Im- proved	11.9	2.3	4.1
17	Renal stones	12.4	2.1	4.2	2-14-34	Hyperplasia, to- tal resection three, subtotal fourth	0	6-25-35	Im- proved	10.8	2.9	3.4
18	Osteoporosis	11.6	2.7	5.8	4-13-34	Total resection single adenoma	Slight,	5-16-35	Same	9.9	2.1	7.6
19	Classic. ? Nephrocal- cinosis	15.3	2.4	14.1	4-24-34	Partial resection single adenoma	Severe	1-11-35	Relieved	9.5	2.9	5.1
20	Renal stones. Osteoporosis	12.4	3.4	7.0	6-13-34	Total resection two adenomata	Slight,	5-20-35	Recur- rent hema- turia	9.8	3.7	3.3
21	Renal stones	11.9	2.9	?	6-16-34	2 adenomata, total resection one, partial sec- ond	Slight,	1-10-35	Urine loaded with W. B. C.	10.3	3.1	
22	Renal stones	12.0	2.7	2.7	7- 6-34	Total resection single adenoma	Slight	10-5-35	Relieved	9.0	2.6	Clinical cure
23	Renal stones. Osteochon- droma	12.9	2.8	5.7	7-12-34	Hyperplasia total resection three, biopsy fourth	Slight, transient	4-12-35	Relieved	9.9	3.2	Clinical cure
24	Renal stones. Paget's +	13.0	2.5	20.0	10-26-34	Total resection single adenoma	Slight,					Has refused follow up
25	Renal stones	13.9	3.0	3.7	10-27-34	Hyperplasia, to- tal resection three, subtotal fourth	Slight, transient	6- 5-35	Relieved	9.7	3.2	Clinical cure
26	Renal stones. Osteoporosis	16.4	2.6	4.8	2- 9-35	Hyperplasia, to- tal resection three, subtotal fourth	0	10- 8-35	Relieved	9.8	3.5	Clinical cure
27	Classic. Nephrocalci- nosis	16.8	2.4	14.1	4-12-35	Partial resection single adenoma	Severe, tetany	10-22-35	Relieved	9.0	3.8	? Clinical cure
28	Classic	13.5	1.5	36.5	6-13-35	Partial resection single adenoma	? Slight, transient	8- 9-35	Relieved	8.5	2.4	? Clinical cure
29	Renal stones. ? Nephrocal- cinosis	11.5	2.4	2.1	7-16-35	Total resection single adenoma	Slight	12-21-35	Im- proved	9.7	2.4	1.4
30	Classic. Nephrocalci- nosis	18.7	2.9	10.4	1-14-36	Total resection single adenoma	Slight transient	5-23-36	Im- proved	9.60	5.00	? Clinical Cure

in our cases it is possible that the occurrence of mild transient tetany would have been avoided entirely. For reasons of academic interest it has been our practice to withhold calcium therapy until definite signs of tetany appeared. From the point of view of rational therapy, however, the patient should be started on the high calcium intake without delay.

If only a positive Chvostek sign appears, no treatment other than high calcium diet is needed. If, however, the Trousseau sign becomes positive and there are definite paresthesias of hands and face, it is wise to prepare for spasms and possible stridor. Large doses of calcium lactate are given by mouth; calcium gluconate and calcium chloride are kept available for immediate intravenous use.

Parathyroid extract is of but limited use in the treatment of postoperative tetany. The injections are often very painful and, more important, a so called immunity develops to limit its use over any long period of time. From a theoretical point of view, except in tetania parathyropriva, supply of calcium is what is needed. Parathyroid extract merely postpones the recalcification of the skeleton. Adjustment of the dosage to allow slow recalcification would be so difficult that we do not recommend its clinical use.

In the tetany of the recalcification period we have but little experience in the use of vitamin D. Theoretically, vitamin D might increase the deposition of calcium, increasing the drop in blood level. If the tetany becomes chronic and is of true hypoparathyroid origin, large doses of vitamin D together with liberal amounts of calcium offer the best method of treatment.

SUMMARY

- (1) A rational basis for parathyroid surgery is defined.
- (2) The complications of renal stone are discussed.
- (3) The normal parathyroid gland is described with particular reference to gross anatomy.
- (4) The pathology of the parathyroid bodies is briefly reviewed, recognizing two major types.
- (5) The technical steps of the operation are outlined.
- (6) The special surgery of generalized hyperplasia is discussed and illustrated by a description of six cases having this type of pathology, three of which are reported in detail.
- (7) In five instances parathyroid tumors have been found that were overlooked at previous operations. The technic of these secondary operations is described.
- (8) The amount of tissue to be resected when pathologic glands are exposed varies with the type of pathology and the nature of the disease in the individual patient. The criteria for radical or conservative measures are indicated.
- (9) Postoperative tetany of two distinct types is described and illustrated by case citations. The treatment of tetany is referred to briefly.

(10) A table is appended summarizing the end-results in 30 cases of hyperparathyroidism treated by operation.

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METASTASES TO THE THYROID GLAND FROM CANCER OF THE COLON

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METASTASES from neoplastic growths usually follow definitely well recognized channels, and appear in certain other viscera with a distinct regularity, depending upon the type and location of the original growth.

Recurrence of colonic and rectal cancer in the thyroid gland is of such extremely small incidence that it is an unique observation. For this reason we wish to report in some detail a case which was followed over a period of four years and the autopsy findings of which revealed, in addition to the customary metastases, one in the thyroid gland.

CASE REPORT

W. N. O., male, aged 54 years, was examined April 28, 1931, having been referred with a diagnosis of carcinoma of the ascending colon with mild obstruction, and in addition, a benign polyp of the sigmoid.

Present Complaint.—Pain in abdomen which came on acutely April 23, 1931.

Present Illness.—Patient states that on April 23, 1931, during the night he began to have some pain in the epigastrium which was griping in character. It came on in paroxysms and seemed to be relieved by the passage of flatus. It was not severe, although it did double him up at times. A small enema gave him some relief. Since this time he has had a few twinges of pain but has not been distended as he was during the acute attack. He has had no previous gastro-intestinal distress of any kind.

About one year ago he noticed blood in the stool, and on proctoscopic examination a small polyp from which blood was oozing was discovered in the rectum. There were several recurrences of this bleeding, the last being in March, 1931, at which time gastro-intestinal series was postponed to allow the bleeding to stop. His appetite has always been good, he has had no colics, jaundice, loss of weight, or vomiting, and has had good bowel movements, having regularly a morning stool, and has no history of any bowel infections or any attacks of alternating diarrhea and constipation.

Previous Health.—General health has been excellent and the history by systems is negative.

Family History.—Father and one elder brother died with coronary attacks, otherwise history is essentially negative.

Marital History.—Wife living and well; four children living and well; one child has congenital bilateral dislocation of the hips.

Physical Examination.—Patient is a well developed and well nourished white male, aged 54 years, a physician, apparently not acutely ill at present. No appearance of jaundice. Blood examination showed white cells, 8,600; red cells, 4,150,000; hemoglobin, 87 per cent. Urinalysis—normal.

Roentgenogram of the chest—negative except for some calcification in the region of the left hilus. No evidence of a metastatic lesion.

Proctoscopic Examination.—Normal rectal lining for 24 cm.

Roentgenologic Examination of Colon.—An annular carcinoma just proximal to the hepatic flexure.

A diagnosis of cancer of the colon having been made, the patient was put on a

preoperative decompressive and rehabilitary regimen, and on May 4, 1931, was operated upon. The operative note is as follows: "There is a cancer of the right colon below the hepatic flexure. No metastases could be discovered. An aseptic ileocolostomy was made over the Rankin clamp between the terminal ileum and the middle of the transverse colon. The cecum was found bound down in the site of an old appendectomy scar. A great deal of fat was in the mesentery of the transverse colon and the operation was technically difficult. Spinal anesthesia had to be supplemented with gas-ether."

Following this preliminary by-passing of the fecal current, the patient was returned to his home to await a subsequent resection which was undertaken on July 13, 1931. The following is the operative note: "Right rectus incision. Resection of the right colon and one-half of the transverse colon, going at least ten inches beyond the hepatic flexure. The resection was accomplished easily and satisfactorily. The end of the colon was turned in and brought out under the skin. The blood supply was satisfactory on inspection. Peritonealization was easily accomplished. A Penrose drain and one split tube were left in the intraperitoneal space for drainage."

Pathologic Report.—"Specimen shows 17 cm. of ileum and in addition, the cecum and ascending colon. Diagnosis.—Annular, Grade II, adenocarcinoma (Fig. 1), 3 cm. long with its proximal margin 9 cm. from the ileocecal junction. There is one node involved."

Postoperative Course.—The patient had a relatively easy convalescence and was dismissed from the hospital during the third postoperative week. He returned home and regained his strength quickly and became actively engaged in his profession. On July 11, 1932, he returned for a re-check, at which time a roentgenologic study of his chest was negative except for the calcification at the left hilus which had been noted at the previous examination; that of the colon showed the anastomosis to be functioning well and no evidence of recurrence in the bowel. There was a diverticulitis of the sigmoid with moderate spasm, which had been noted at his first examination.

The patient continued in robust health, and practised his profession actively until the late summer of 1934 when he began to become fatigued more easily than normal but without any very definite symptoms of a return of malignancy. A roentgenologic study of the stomach and bowel on July 28, 1934, was negative, as was that of his chest.

He continued to work until the middle of December, 1934, when it became evident that he was losing ground. A check-up at this time was undertaken because of a paralysis of his right vocal cord, which developed suddenly. A roentgenogram of his chest at this time did not show definite metastases and no lumps were palpable in the abdomen, nor was the liver apparently enlarged, but the thyroid gland was definitely enlarged and some small lymphatic nodes, which were hard, could be felt in the triangles of the right side of the neck.

In January of 1935 he began to decline rapidly and was confined to his home. On March 3, 1935, he died.

Autopsy.—The body is that of a man appearing older than the stated age of 58. External examination shows moderate emaciation. There is a swelling on the right side of the neck along the course of the anterior chain of cervical lymph nodes extending across to the region of the thyroid gland and giving rise to a mass 6 by 6 by 3 cm. lying above the right clavicle. There is slight enlargement in the region of the left lobe of the thyroid. The surgical scars on the right side of the abdomen are in no way remarkable.

On opening the abdomen, no free fluid is found, but the omentum is tightly bound by old adhesions to the abdominal wall and to coils of small intestine in the right iliac fossa. The cecum, ascending colon, and hepatic flexure are absent, the transverse colon being closed blindly and anastomosed to a loop of ileum. The anastomosis is widely patent and there is no evidence of neoplasm in the bowel or tissues adjacent to the

operative site. The remainder of the colon, the small intestine, and the stomach are normal.

The liver is markedly enlarged, extending 5 cm. below the right costal margin and projecting well over into the left upper abdominal quadrant. Section shows the right lobe to be practically entirely replaced by a neoplastic mass, while there are smaller metastases throughout the left lobe. The gallbladder is not involved by neoplasm, but the common bile duct is surrounded by a mass of tumor which has caused a partial obstruction. The pancreas, while lying in close proximity to a mass of cancerous nodes, is not involved by metastases.

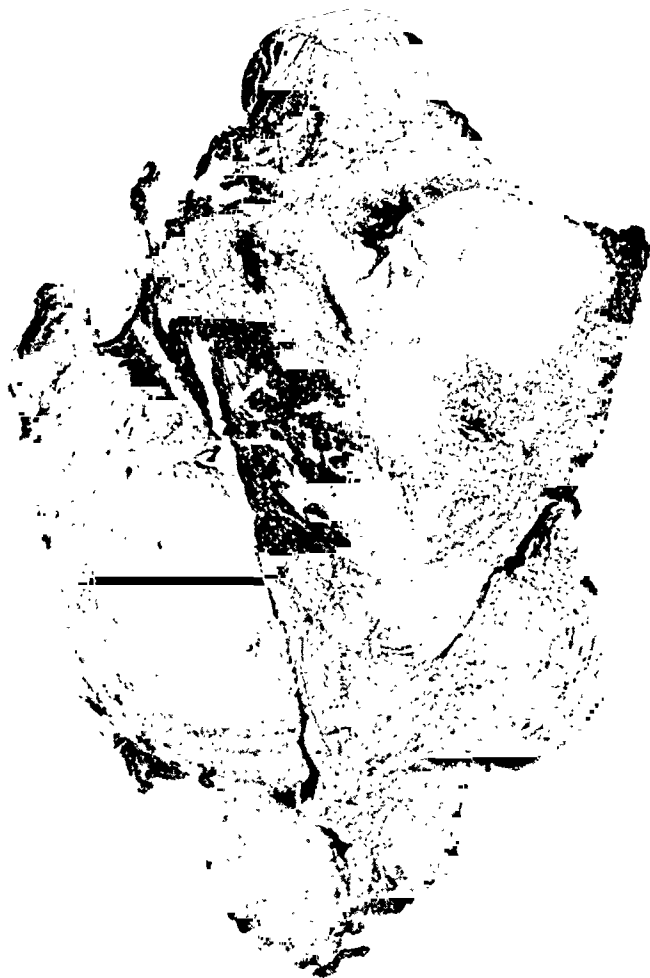


FIG. 1.—Photomicrograph from section of operative material removed in 1931. The diagnosis is Grade II adenocarcinoma. The microscopic appearance is very similar to that seen in sections from the liver and lungs removed at autopsy four years later.

Anterior to the vertebral column is a continuous chain of neoplastic lymph nodes, extending to and involving the bronchial nodes. Both kidneys show marked metastatic involvement, that on the right being much more extensive. A tumor mass replaces the medulla of each adrenal, being surrounded by a thin yellow ring of cortical tissue. The cancer nodule in the right adrenal measures 6 by 4 by 4 cm. and that in the left 2 by 1.5 by 1 cm. The spleen, while enlarged, shows no evidence of neoplasm. The urinary bladder and genital organs are not unusual.

Within the chest no excess of fluid is found in any serous cavity. In the lower lobe

of the right lung is a large mass of neoplasm over which is recent fibrinous pleuritis binding visceral to parietal pleura. Scattered throughout both lungs are metastases varying in size up to 3 cm. in diameter. The lower left lobe is red and firm, typical of consolidation. The heart is smaller than normal and the musculature has a chocolate color. The right side is dilated. There is moderate sclerosis of the coronary vessels and the mitral valve cusps are thickened. Moderate atheromatous change is present in the aorta.

The neck organs, trachea and mediastinal structures were removed *en masse*. The cervical nodes on the right are completely replaced by neoplastic tissue. In the right lobe of the thyroid is a tumor mass measuring 4 by 2 by 2 cm. and in the left lobe a similar mass measuring 3 by 1.5 by 1 cm. No normal thyroid is discernible on gross inspection. There is a cancerous area in the mucosa of the larynx on the right side just below the vocal cord.

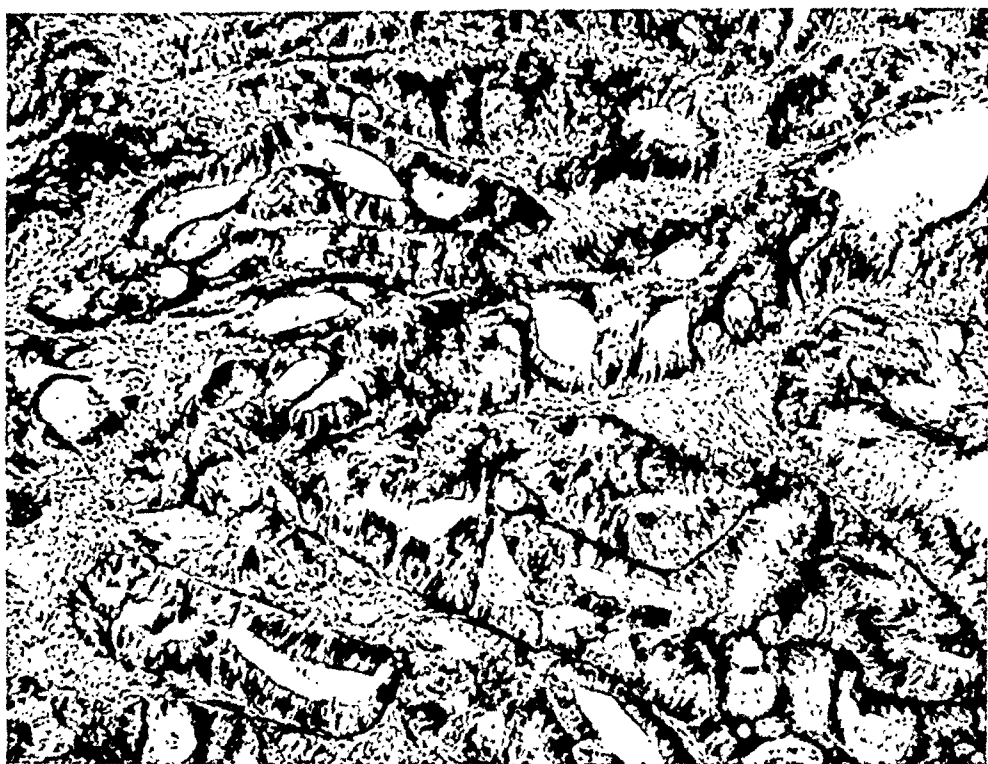


FIG. 2.—Dissection of thyroid and larynx. The thyroid has been sectioned, showing the large white mass of neoplasm replacing the right lobe. The left lobe has more the appearance of normal thyroid and does not reveal in the photograph the large amount of neoplastic infiltration which is present.

Tissues from all organs—except the brain, which was not removed—were examined microscopically, but only those showing neoplasm are reported here (Fig. 2). In the lungs, which also show areas of acute edema and foci of acute purulent lobular pneumonia, the metastases show definite adenomatous architecture similar to that seen in the operative material. The carcinoma cells are in many areas mucin producing. The smallest metastases are in the lumina of blood vessels. The neoplasm in the liver is quite similar to that in the lungs. In the kidneys the differentiation is less marked and there is some necrosis. Both adrenal medullae are completely replaced by metastatic carcinoma, but the thin layer of cortex surrounding the tumor is normal in appearance except for small inflammatory foci. The most undifferentiated areas are in the lymph nodes and in the thyroid, where the adenomatous architecture, although still present, is less well preserved and the cells show many mitotic figures. There are large areas of caseation necrosis in the neoplasm. The right lobe of the thyroid is entirely replaced by carcinoma, only a few small islands of recognizable thyroid tissue being present. The left lobe is infiltrated throughout by neoplasm, but there is considerable remaining thyroid tissue.

Pathologic Diagnosis.—Generalized adenocarcinoma (primary lesion in previously removed ascending colon). Multiple metastases in prevertebral lymph nodes, liver, larynx, both adrenals, lungs and both lateral lobes of the thyroid. Terminal purulent lobular pneumonia. Early atheromatous changes in aorta and coronary vessels. Brown atrophy of heart. Serous atrophy of fat tissue. Cloudy swelling of all parenchymatous tissues.

The point which distinguishes this case from an ordinary generalized carcinomatosis is the occurrence of metastases in the thyroid. As has been repeatedly noted, cancer of the large bowel is less apt to produce distant metastases than neoplasm arising elsewhere in the gastro-intestinal tract. Further, carcinoma in the upper portion of the colon is less prone to distant spread than that occurring in the rectum. The mucin formation in this tumor is deserving of further comment. As pointed out by Rankin and Chumley, mucin production in colonic tumors is of two types. In the first group there are many goblet cells and the mucoid change represents a differentiation of the carcinoma toward the normal function of colonic mucosa. These tumors are not prone to distant metastases and are among the less highly malignant of intestinal cancers. The other group is highly undifferentiated and the mucin is present within highly atypical cells—the so called signet-ring cells. These tumors are highly malignant and are prone to metastasize early and widely. The mucin formation in this particular carcinoma is of the first mentioned type. The spread of this neoplasm has been by both hematogenous and lymphatic routes. The involvement of the thyroid is undoubtedly by way of the adjacent carcinomatous cervical lymph nodes. In spite of the proximity, however, such an occurrence is extremely rare. In carcinoma of the colon it is even less frequent and in the particular type of cancer represented by this case, it is most unusual.

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THE FALL IN BLOOD PRESSURE DURING SPINAL ANESTHESIA

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FATALITIES have been numerous after the subarachnoid injection of anesthetic drugs. Fortunately, these are becoming less and less frequent. However, such accidents are still common enough to warrant further investigation into the mechanism which produces such a rapid and marked fall in blood pressure, and leads to a state simulating shock and occasionally to death of the patient. Many theories have been proposed and many experiments performed in an effort to determine the cause of this fall in blood pressure. Important facts have been brought to light, but none of them seems quite adequate.

A brief résumé of the prevalent ideas concerning the cause of the fall in blood pressure reveals the confusion that exists. The following have been given as causative factors:

(1) Muscular relaxation and diminished negative intrathoracic pressure due to abdominal and lower thoracic paralysis—Gray and Parsons.¹

(2) Splanchnic dilatation—Smith and Porter.²

(3) Cerebral anemia due to splanchnic dilatation—Labat.³

(4) Diffusion of the anesthetic into the medullary region—CoTui and Standard.⁴

(5) Vascular absorption of the anesthetic and its subsequent systemic effects—Nowak.⁵

(6) Vasomotor paralysis and sudden absorption into the blood stream of novocaine—Jones.⁶ Jones states that sudden absorption is by far the greater factor. No experimental proof is offered to substantiate the vasomotor paralysis theory.

Since vasomotor paralysis has been mentioned so frequently as a causative factor, it was decided to sympathectomize animals completely, thus eliminating the vasomotor control, and see what effects, if any, the subarachnoid injection of procaine would have on the blood pressure of these animals.

Procedure.—Five healthy cats were anesthetized by the intraperitoneal injection of sodium barbital (.45 Gm. per kilogram). A carotid cannula was inserted for recording blood pressure. The animals were then subjected to a laminectomy at the second or third lumbar level. Metz procaine crystals were dissolved in normal saline to make a 10 per cent solution. To each cubic centimeter of this solution was added one drop of aniline gentian violet. Each animal was given 10 mg. of procaine for each kilogram of body weight. This dosage is four or five times the amount usually given to patients. The gentian violet allowed the determination of cord level reached by the colored solution and the detection of any leakage about the needle puncture in the

dura. The dural puncture was made under direct vision always at the second or third lumbar level. By means of a time marker on the kymograph record the rate of injection could be kept fairly constant.

Figure 1 is a typical record. All the control animals showed a lowering of blood pressure, of the same order of magnitude as did Nowak's⁵ control animals. Table I shows the uniformity of these results.

TABLE I
SPINAL ANESTHESIA IN NORMAL ANIMALS

Experiment No.	Wt. in kilos.	Height of colored fluid	Blood pressure	
			Before	Lowest after
2	3.25	7C.	90	60
5	3.50	4T.	135	60
15	3.15	5T.	95	60
16	3.17	5T.	120	60
17	3.52	4T.	130	90

Four cats were completely sympathectomized in stages, the thoracic chain on one side and both abdominal chains being removed at the first operation. A recovery period of ten days to two weeks was allowed and the remaining thoracic chain was taken out. A second recovery period of ten days was allowed before making the subdural procaine injection. Occasionally the entire sympathetic chain of one side was removed intact, including the stellate in the neck and ganglion impar at the coccyx.

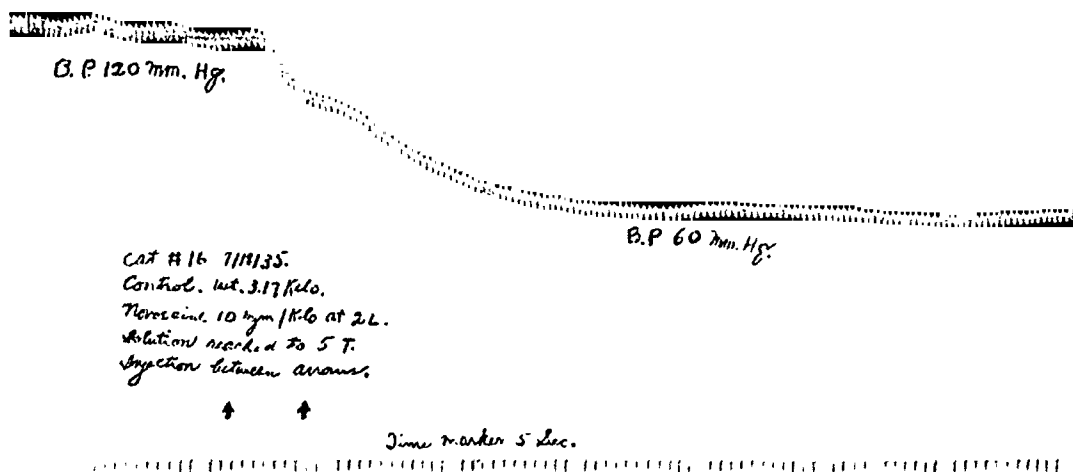


FIG. 1.—Normal cat. Weight, 3.17 kilo. Subarachnoid injection of 10 mg. novocaine per kilo at second lumbar level. Colored solution extended to fifth thoracic level.

These animals were then subjected to exactly the same procedure as the control animals. Fig. 2 is a kymographic record of one of these experiments. The other records are all similar. It clearly shows the difference in blood pressure response to subdural procaine injection in this and the control animal. Table II shows a similar response in all the sympathectomized animals.

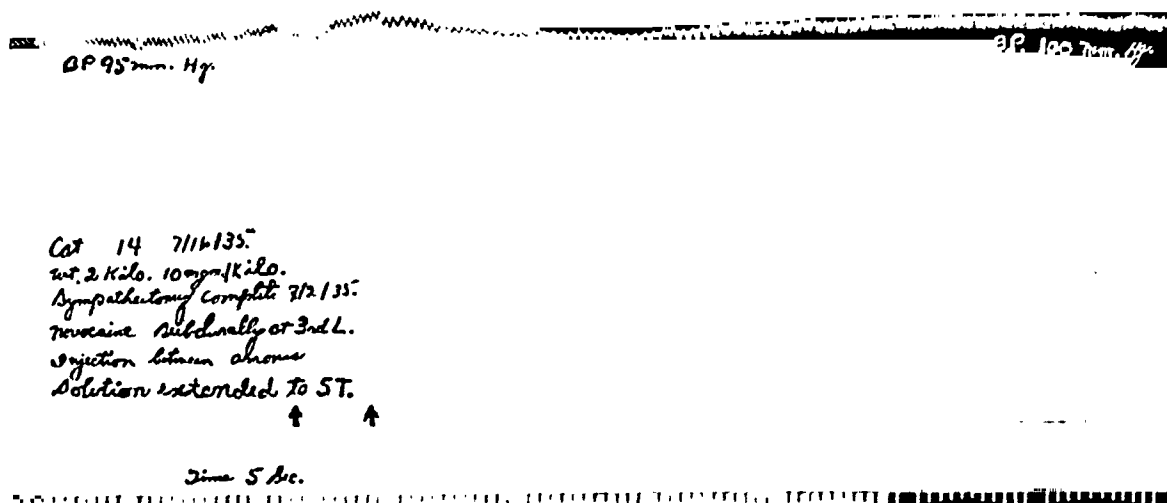


FIG. 2.—Sympathectomized cat. Weight, 2.0 kilo. Subarachnoid injection of 10 mg. novocaine per kilo at third lumbar level. Colored solution extended to fifth thoracic level.

TABLE II

SPINAL ANESTHESIA IN SYMPATHECTOMIZED ANIMALS

Experiment No.	Wt. in kilos.	Height of colored fluid	Blood pressure	
			Before	Lowest after
4	3.70	7C.	80	75
7	2.21	4T.	95	90
12	2.30	5T.	80	85
14	2.00	5T.	95	100

Comment.—These experiments demonstrate the rôle of the vasomotor system in the fall in blood pressure that occurs during spinal anesthesia. This fact has long been recognized by some surgeons on more or less empirical grounds. So far as we are aware, it has never been clearly demonstrated in a series of experimental animals.

Although it is true that in the sympathectomized animals the blood pressures are lower before the subdural injection is made, cats number 2 and 15 in the control group also had a low blood pressure before the procaine was injected. They both had definite falls in pressure, however, after the injection.

From these studies there is no indication that the height of the anesthesia, within limits, is of great importance in causing the fall in blood pressure. In the control series there was no greater fall when the colored solution reached the seventh cervical level than when it had reached only the fifth thoracic level. It would appear, therefore, that the vasoconstrictor fibers from the fifth thoracic level down are the important fibers in the most common type of blood pressure reaction occurring under spinal anesthesia.

When high concentrations of the anesthetic drug reach the cervical cord and higher regions, respiratory failure occurs. Schief and Zieg-

ner⁷ tied ligatures around the dura in the upper thoracic cord and made injections above these ligatures. This led to respiratory failure. Thompson⁸ made injections into the ventricles and the cisterna magna which produced respiratory failure followed immediately by a fall in blood pressure. When lumbar injections were made there resulted an immediate fall in blood pressure, an apparent paralysis of intercostal muscles, and a gradual failure of diaphragmatic respiration. If the lumbar injection was preceded by ephedrine this series of events did not occur. Ferguson and North⁹ observed respiratory collapse when the injection was made above a ligature at the eighth cervical level. They also demonstrated marked falls in blood pressure with variable effects on respiration when the injection was limited to the region between the eighth cervical and the fifth or sixth thoracic segments. These authors state that the entire vasomotor system participates in a vasodilation and the degree of blood pressure depression is in direct ratio to the number of white rami anesthetized.

It seems reasonable to assume that in some instances sufficient concentration of a drug used for spinal anesthesia may be present in the higher cord region and produce complete intercostal paralysis, phrenic paralysis, and paralysis of medullary centers, in addition to complete sympathetic nerve paralysis. However, such a condition must be rare. It seems extremely unlikely that such a concentration can exist if the drug had been injected in proper dosage and with proper technic, in the lumbar subarachnoid space. It is also assumed that occasionally during the subarachnoid injection of a drug a vein may be entered with the sequence of events described by Hatcher and Eggleston¹⁰ as following the rapid injection of procaine into a vein.

From a practical point of view it would seem that certain measures are indicated by these experiments to prevent his fall in blood pressure.

(1) The preliminary administration of some vasoconstrictor drug which produces constriction by direct action on the arterioles. Probably ephedrine is the best drug available at present.

(2) The use of small doses of drugs employed for spinal anesthesia.

(3) The limitation of drugs injected subdurally to small segments of the spinal cord so that as few vasoconstrictor fibers as possible are paralyzed.

CONCLUSION

The fall in blood pressure following the injection of procaine for spinal anesthesia is due to a paralysis of vasoconstrictor nerve fibers.

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EVIPAL ANESTHESIA IN THORACIC SURGERY*

STUDIES IN ONE HUNDRED THORACOPLASTIES FOR PULMONARY TUBERCULOSIS

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THE reason we were induced to try Evipal in our thoracoplasties for pulmonary tuberculosis is that we do not as yet possess the suitable anesthesia for these cases. In our work at Sea View and Metropolitan Hospitals of the City of New York, in which an average of 400 thoracoplasties have been performed yearly during the past four years, we have successively used spinal, local and general anesthesia, alone or combined, without complete satisfaction. Spinal anesthesia was discarded because of the frequently marked drop of blood pressure caused by it, which could not always be controlled; local anesthesia, because it seldom insured the painless operation which is necessary in patients who have to be submitted to several stages. General anesthesia with gas-oxygen-ether was the simplest and most satisfactory, except for the fact that it predisposes to the development of respiratory complications during and after operation. As has been previously demonstrated,^{7, 8} these patients are in a state of chronic anoxemia and are therefore particularly vulnerable to even slight disturbances of respiration. Accumulation in the trachea of bronchial exudate during thoracoplasty is sufficient to cause acute anoxemia and to start the vicious cycle of rapid shallow breathing, acapnia, periodic breathing, drop of blood pressure and rapidly increasing oxygen unsaturation of hemoglobin, which leads to fatigue of the respiratory center and apnea. Still more dangerous are postoperative pulmonary inflammatory complications which are responsible for nine-tenths of our postoperative morbidity and mortality.⁹ Although we do not accept the so called postoperative ether pneumonia,⁷ we are obliged to recognize that any marked limitation of the respiratory field, already restricted by the tuberculous lesions of the lung and the collapse of part of this organ produced by the operation, may suffice to start the above-mentioned cycle. Prolonged postoperative sleep and suppression of the cough reflex favor bronchiolar obstructions, which are the principal factors in the production of postoperative lobular or lobar atelectasis, bronchopneumonia and pneumonia (Coryllos and Birnbaum¹¹). Therefore, the ideal method of anesthesia in these cases appears to be one which would insure the patency of the respiratory ways, the removal of exudate expressed from the lung collapsed by the operation, the prevention of its draining into the bronchi of the healthy lung and the rapid reestablishment after operation of the natural means of defense of the lung and more especially of the cough reflex.

We have partly satisfied these requisites by the use of an intratracheal

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catheter which insures patency of the respiratory ways and allows removal of the bronchial exudate by suction during operation.^{7, 8} Furthermore, by packing the oropharynx around the catheter we have obtained separation of this cavity from the larynx and thus have been able to prevent passage of infected secretions from the upper into the lower respiratory tract. The marked improvement in the results in the last 600 thoracoplastic operations has shown the efficiency of this procedure.^{9, 10}

In order to decrease the amount of anesthetic administered through the respiratory passages, we have used avertin¹⁰ as a basal anesthetic in some 300 thoracoplastic operations at Sea View and Metropolitan Hospitals. The dose was kept under 80 mg. per kilogram of body weight. This procedure rendered possible the use of more liberal amounts of oxygen during operation and of more frequent bronchial suction. However, it presented two important inconveniences: first, a period of more or less marked agitation and restlessness following operation, which greatly increased the metabolic needs of oxygen of these already anoxemic patients; second, it was often followed by a prolonged sleep during which the patient did not cough or expectorate, which favored stagnation of the exudate in the bronchial tree.

For these reasons we decided to try a new compound of barbituric acid, known as Sodium Evipan in Europe, and recently introduced into this country under the name of Evipal Soluble. The rapid oxidation in the organism and elimination of this product, the shortness of anesthesia produced by it, its relatively large margin of safety and the facility of its administration, recommended it for our work. A previous careful timing of the different stages of our thoracoplastic operations, all performed by the technic previously described,¹⁰ had shown us that the average time for a first stage was from 20 to 45 minutes and for the second and third stages from 15 to 30 minutes; therefore it appeared that if we administered this anesthetic just before the beginning of the operation we could carry on the operation or at least the longest part of it without any additional anesthetic. One hundred thoracoplasties were performed under Evipal anesthesia by this procedure. In every case the anesthesia was given by one of us (S.B.) and conducted as a physiologic experiment. The time of the administration of the anesthetic was registered, blood pressure, pulse and respiration rates were taken every three minutes, the condition of the reflexes, the color of the patient and such phenomena as cyanosis, tremor, *etc.*, were carefully noted. In a number of cases in which gas-oxygen or oxygen-carbon dioxide was added, the blood pressure, respiration and percentages of gases were recorded by means of the anesthesia recording apparatus of McKesson.

We wish to report here the results obtained in these 100 consecutive cases of thoracoplasty for pulmonary tuberculosis, in which the results have been consistently favorable.*

TECHNIC.—In our work we have used the product known as Evipal Soluble.

Preliminary Medication.—In all of our cases we use grain 1/3 of pantopon

* The results of a new series of 300 cases were published recently.²³

one-half hour before operation. Ephedrine grain $\frac{3}{4}$ was given hypodermically just before the administration of the anesthetic, in a few cases. We found that ephedrine checked considerably the tendency of Evipal to produce an immediate and marked drop in blood pressure. No other barbiturates were used before operation.

Injection.—As the duration of anesthesia is very short (10 to 30 minutes) we adopted the technic of placing the patient on the operating table, which is a rather long procedure in thoracoplasties, and of preparing the field and placing the sterile sheets, before the injection of the anesthetic. When the intratracheal catheter was used, as was done on all patients expectorating over 20 cc. of sputum in twenty-four hours, it was introduced beforehand under local anesthesia of the throat and larynx with 2 per cent nupercaine. The solution of Evipal was then slowly injected into a vein in the arm.

Dosage.—In order to determine the amount necessary to produce sleep (hypnotic dose) the patient was asked to count in a loud voice, or in cases in which the intratracheal catheter was used and the patient could not talk, he was instructed to count by moving the fingers.

The determination of the hypnotic dose is of importance because it allows an estimate of the total dose which can be given safely. Menegaux and Sechelaye²³ have analyzed over 23,000 cases of Evipal anesthesia. In this paper they consider relaxation of the masseter muscles and the "drop of the jaw" as the best criterion of the onset of sleep. "The drop of the jaw" according to these authors "is more sudden than in any other kind of anesthesia." The dose necessary to produce this phenomenon can be doubled without danger and should be, in order to obtain the full effect and duration of anesthesia with Evipal. We have not been able to corroborate the relaxation of the masseter muscles. Very often little or none was obtained and in some cases the opposite effect was noticed. Therefore as the criterion of the hypnotic dose we have elected the number of cubic centimeters given until the onset of sleep, indicated by cessation of counting by the patient. This dose can be safely doubled.³³ In this series, however, without disregarding this point, we have routinely injected, with only a few exceptions, 10 cc. of the 10 per cent solution, that is, 1 Gm. of Evipal; and have not employed more than this amount.

The sleep caused by Evipal is comparable to natural sleep. The patient rapidly loses consciousness without any disagreeable sensation. The narcotic effect is evidenced by moderate snoring, often by cough, sometimes by tremor of short duration. Generally 4 cc. suffices to produce sleep and slight analgesia.

The dosage of anesthetic according to the weight of the patient seems to be of importance, especially in emaciated subjects. There can be no doubt that by giving all patients the same dose of Evipal (1 Gm.) we get a more marked anesthesia and a more prolonged narcotic action in lighter rather than in heavier patients. However, the dose of 1 Gm. has proven to be without untoward effects in patients weighing as little as 85 pounds

when injected slowly, provided they were not toxic. It has been shown that in patients weighing less than 100 pounds the duration of complete anesthesia was from 49 to 27 minutes, an average of 31 minutes; in only two instances was additional anesthesia necessary. The time that elapsed from the administration of the anesthetic to the return to consciousness varied in these cases from a minimum of one hour and ten minutes to seven hours and 57 minutes, an average of three hours and 30 minutes. On the contrary, in cases weighing over 150 pounds, the duration of complete anesthesia varied from eight to 27 minutes, an average of 15 minutes, and they were fully conscious from one to three hours and 49 minutes, an average of two hours and 15 minutes. In all of these latter patients except one additional anesthesia was necessary.

Speed of Injection.—It is generally recommended to inject no more than 1 cc. every ten seconds. We have always followed this rule. Monad²⁵ and Jentzer¹⁰ have insisted on the advantages of slow injection in order to avoid any "blood wave oversaturated with Evipal" from coming in contact with the bulbar centers. Bennhold² showed that the proteins of the blood have a limited ability to combine with Evipal, and following a massive and rapid injection, this substance may remain free and damage the centers of the bulb. Rostock²⁸ and Menegaux and Secheyaye²³ attributed four instances of transient apnea to an excessive speed of injection. Furthermore, accurate determination of the hypnotic dose can be obtained only by slow injection. On the other hand, Anschütz¹ has shown that too slow an injection may cause failure of anesthesia, as the rapidity of the destruction of the substance in the organism may prevent it from reaching the degree of concentration necessary for the induction of anesthesia. In our cases we have found that the best anesthesia was obtained by injecting 1 cc. in ten seconds, an average total time of 100 to 120 seconds for 10 cc.

COURSE OF ANESTHESIA.—As has already been stated, the induction of anesthesia is smooth and without any objective or subjective symptoms. The patients present the aspect of natural sleep. Occasionally there is a slight cyanosis, or a slight tremor which are transient. It is seldom that generalized tremor has been observed. The only really alarming symptoms are excessive pallor and apnea which may follow very rapid injection or overdosage. We had no such complications in this series.

Reflexes.—The corneal reflex disappeared as the narcotic dose was reached. The reflex to light, on the contrary, persisted in a number of cases. In a few instances the corneal reflex persisted, although a good anesthesia was obtained. In a general way the pupils contracted at the onset of the anesthesia and then gradually dilated. More frequently the condition of the pupils varied to such an extent that it could not serve as a guide for the anesthetist as in inhalation anesthesia.

Opinions are at variance concerning the action of Evipal on the laryngeal reflex. Kriebel²⁰ reported that it is always abolished whereas in all of Ropke's cases it had persisted. We do not entirely agree with Ropke, as

in two cases of bronchoscopy and esophagoscopy we were obliged to postpone the procedure because of the persistence and even an increase of the reflexes of the pharynx, larynx and bronchi. In all of these cases these procedures were carried out a few days later under local anesthesia with 2 per cent nupercaine without any difficulty.

Pain reflex, especially during incision of the skin, was present in five cases, and was manifested by a more or less marked movement of the patient. However, in all these cases, section of the muscles and periosteum and resection of the ribs were painless.

Action upon Circulation and Respiration.—Of far greater importance are the changes occurring in the blood pressure, and in the rate and quality of pulse and respiration. All of our cases were analyzed and segregated to operative stages, in order to determine the respective effects of the anesthesia and of the operation upon these phenomena. Although the first stage of thoracoplasty is longer in duration and causes more shock than the second and third stages, it should not be forgotten that the patient often comes to the second and third stages in poorer physical condition than he was in the first stage. In the majority of these cases the variations of blood pressure were very marked. In 27 of our 100 cases the blood pressure fell within one to two minutes following the injection of Evipal, and could not be obtained; this condition lasted from two to five minutes. We wish to state, however, that the drop was not accompanied by any symptoms of shock; it had little effect upon the color of the patient or the rate of respiration. The pulse was palpable in all cases, in the temporal artery. Therefore this initial drop of blood pressure should be differentiated from any later drop which is due to postoperative shock.

At the beginning of this investigation, two cases were operated upon under combined local infiltration with novocain and Evipal anesthesia. In both, within three minutes after injection of Evipal, the blood pressure could not be obtained; the same fall of blood pressure occurred in a third case, although the initial systolic pressure was 144 Mm. Following this experience we adopted the procedure of injecting, routinely, one ampoule of ephedrine, gr. $\frac{3}{4}$, subcutaneously, immediately before the injection of Evipal, and have considerably decreased the instances of marked drops in systolic pressure, without, however, being able to eliminate them completely.

In five cases in which no ephedrine was used, the average drop was 92 Mm., from an average initial systolic pressure of 130 Mm. (*i.e.*, 70 per cent of the initial pressure). In our calculations we have accepted that the systolic pressure is around 40 Mm., when it cannot be registered in the arm, although the pulse can be felt in the temporal artery. In the cases in which ephedrine was used the average drop was 25 Mm. on an average initial pressure of 129 Mm. (*i.e.*, 19 per cent of the initial pressure). In all cases, except one, in which marked operative shock developed, the pressure returned to practically normal levels at the end of the operation. Therefore it seems reasonable to consider that this initial drop of blood pressure was due to

Evipal and not to the operation. Likewise the differences between initial and terminal pressures were not greater following first stage thoracoplasties, than following second or third stage procedures. Thus in 48 first stages the average of the initial systolic pressure was 123 Mm.; the average at the end of the operation was 104 Mm., an average drop of 19 Mm., representing 15 per cent of the initial systolic pressure. In 38 second stages the average initial systolic pressure was 127 Mm., and at the end of the operation 108 Mm., a drop of 16 Mm. (*i.e.*, 13 per cent. of the initial pressure). In 12 third stage operations the average initial systolic pressure was 138 Mm. and at the end of the operation 117 Mm., an average drop of 21 Mm. (*i.e.*, 15 per cent of the initial systolic pressure). In other words, the drop was approximately the same in all stages notwithstanding the considerably greater traumatism caused by the first than by the second and third stages. It is reasonable, therefore, to conclude that the drop at the end of the operation was due to the anesthetic.

The fall of blood pressure caused by Evipal is better appreciated when we consider the drop occurring one to three minutes following injection. In our 43 first stages, the average initial pressure was 123 Mm. If we admit that the systolic pressure in cases in which it could not be recorded with the sphygmomanometer was approximately 40 Mm., we find that the average lowest pressure was 74 Mm. mercury, that is an average drop of 50 Mm. (40 per cent). In the 38 second stages with an average initial pressure of 127 Mm. the average lowest pressure was 49 Mm., an average drop of 78 Mm. (61 per cent). In the third stages with an average initial pressure of 138 Mm. the average lowest pressure was 88 Mm., a drop of 50 Mm. (36 per cent). Thus following Evipal injection there was an average drop of 46 per cent within five to 15 minutes.

We wish to stress, however, the point that since we have been using Evipal anesthesia the number of cases of operative shock has been markedly reduced. In the present series of 100 consecutive operations, from August 7 to November 20, 1934, there was only one case with marked postoperative shock; and this was the only operative death occurring among them.

PULSE AND RESPIRATION.—In all cases the pulse was markedly accelerated during operation with a tendency to slow down at the end. In three it was slightly lower at the end of the operation and in two it remained unchanged. In one-third of our cases the pulse was more rapid than normal before the anesthesia, due to the apprehension of the patient during preparation. During the operation it varied between 110 and 165, averaging approximately 150, which has obtained in our thoracoplasties, irrespective of the kind of anesthesia employed. It was also noted that the average pulse rates were about the same in cases with Evipal anesthesia alone or combined with gas-oxygen. In general, we believe that a rapid pulse is of no great significance in these cases as long as it remains regular and of good quality.

The respiratory rate is of great significance to the anesthetist, as it is readily influenced by barbituric compounds. In no case did we observe any

slowing of respiration which would indicate a toxic effect of the anesthetic upon the respiratory center. Neither did we notice any mechanical disturbances of respiration due to paralysis of the masseter muscles and "drop of the jaw" as reported by Menegaux and Secheyaye and Jarman and Abel.¹⁸ No apnea occurred in our cases. We had no asphyxial phenomena, due to mechanical obstruction of the glottis by mucus, because in all of our cases with excessive expectoration we used the author's intratracheal catheter.

Respirations as a rule were faster by ten to 20 a minute at the end of the operation than at its beginning. In cases in which no additional anesthetic was given we were impressed by the regularity of both rhythm and depth of respiration and of the slight influence upon them of the rather wide variations of blood pressure and pulse rate. During operations upon the chest the rate and, more especially, the rhythm and depth of respiration are our most valuable guides. It is our impression that in thoracoplasties under Evipal anesthesia we had more satisfactory respiration than with general anesthesia, either alone or combined with avertin.

COMPLICATIONS.—In 100 operations analyzed we did not have any serious complications either during or after operation. Slight cyanosis occurred in seven cases and was rapidly relieved by oxygen-carbon dioxide inhalations. Tremor developed in 11 cases; in five it was very slight and lasted only a few seconds; in one it was limited to the left upper and lower extremities; in one in the left hand, and in another it was generalized. In three cases tremor lasted about one minute.

Slight cough denoting irritation of the larynx and trachea was noticed in seven cases. It ceased as the patient became unconscious.

Apnea was not observed in our cases, either from toxic action of the drug upon the respiratory center or from mechanical obstruction of the larynx by the drop of the jaw. In no case have we noticed either hiccough, extreme pallor, or impending asphyxia.

No important postoperative complications developed. However, restlessness, which is very frequent following anesthesia with sodium amytal or avertin, was noticed in 23 cases, in eight of which it was rather marked but of short duration. Injections of coramine and strychnine had allayed the restlessness in all but two cases; these required an injection of pantopon. We have used pantopon with satisfaction together with strychnine as advised by Cailleret⁵ and more recently by Duboucher,¹³ who gives routinely 0.01 Gm. of strychnine at the end of the operation. The percentages of restlessness in our cases was 23 per cent, more in agreement with Sailer²⁹ and Pauleit²⁶ (15 and 21 per cent) than with the majority of authors who claim only 2 or 3 per cent. However, Duboucher¹³ notes 30 per cent before the use of strychnine.

Vomiting developed in 39 cases. There is no doubt that Evipal itself causes postoperative vomiting because in 14 of these cases no additional gas-oxygen anesthesia was used. However, of six cases which had repeated vomiting only two had had Evipal anesthesia alone, whereas the other four

had had supplemental gas-oxygen. In 42 cases in which only Evipal was used vomiting occurred in 16 cases (39 per cent); in 58 cases in which additional anesthesia was used vomiting was noted in 23 cases (40 per cent). In all but six cases there were one to three vomitings following operation, causing no disturbance to the patient. It is probable that Menegaux and Sechey²³ who reported only 2 to 3 per cent of vomitings have considered only cases with severe vomiting, unless we must attribute our higher percentage to the pantopon given before operation.

Shock occurred in six cases. None was apparently due to the anesthetic, and all but one recovered shortly after operation. As previously stated, complete consciousness returned within from 32 minutes to a few hours. Anesthesia was followed by complete amnesia, which is certainly most gratifying to the patient.

There was no complaint of headache. Thirst was always present. However, the routine intravenous injections of 500 cc. of 5 per cent sodium chloride immediately following operation undoubtedly played a rôle in producing thirst.

MORBIDITY AND MORTALITY.—Postoperative pulmonary morbidity has greatly decreased by this method of anesthesia; the persistence or, at any rate, the rapid reestablishment of the cough reflex helped to prevent the occurrence of pulmonary complications. One death, only, occurred in these 100 operations. This was due to operative shock.

In a general way, in this series with Evipal anesthesia the postoperative course was markedly more smooth than that following any other anesthetic used thus far.

Although we have been particularly fortunate with the employment of this anesthetic, we must not disregard the fact that a number of serious accidents and even deaths have been reported by others. Menegaux and Sechey have collected 49 cases in which serious accidents followed the use of Evipal, without terminating in death and 22 cases in which death occurred. In ten of the latter autopsy was performed.

Accidents Without Death.—In 42 of the 49 cases, the accidents observed were apnea, Cheyne-Stokes respiration, shock and cardiac failure. In other words, 85 per cent of all accidents were cardiorespiratory complications. In four cases prolonged sleep lasting from three to ten hours was observed. In one case with prolonged sleep for ten hours a diagnosis of "hepatic coma" was made. This patient had an obstructive jaundice. In 20 cases the time of occurrence of the accidents was reported; in 18 of them (90 per cent) the accident occurred immediately within one to five minutes following injection. In one case of mastoiditis three arrests of respiration occurred shortly after awakening. In one, signs of meningitis occurred on the third day, without any pathologic changes being found in the spinal fluid. All of these recovered by means of artificial respiration and the use of oxygen-carbon dioxide inhalations, lobelia, coramine and icoral. It is difficult to assign a definite cause to these complications. In 19 (38 per cent) there

was a general sepsis or pronounced toxemia. In two patients who were in good condition apnea occurred following injection of large doses of 16 to 20 cc. of the 10 per cent solution of Evipal. Of the three cases in which prolonged sleep was observed, two had obstructive jaundice, and one had acute yellow atrophy.

From the study of the above cases we can draw the following conclusions: that advanced lesions of the liver constitute definite contra-indications to the use of Evipal, although in these cases any anesthetic is dangerous. This holds true also in cases with advanced sepsis or toxemia such as follows prolonged intestinal obstruction. The most frequent accidents are related to the respiratory centers. This fact should always be borne in mind and an overdosage, or a very rapid injection of Evipal, should be carefully avoided. Almost all of the cardiorespiratory accidents mentioned above occurred immediately after injection and were readily relieved by artificial respiration and oxygen-carbon dioxide inhalations.

Accidents Followed by Death.—An analysis of the 22 lethal cases reported shows that in 18 (82 per cent) there was a marked degree of sepsis or toxemia, such as Ludwig's angina, gangrenous phlegmon of the chest wall, generalized peritonitis, *etc.* In only three cases may Evipal be considered as responsible for the death. However, in one of them, a patient upon whom cholecystectomy was performed, 15 cc. of the 10 per cent solution of Evipal were given and death occurred the next day; furthermore, there was a temperature of 104° F., which indicated an operative rather than an anesthetic death. More puzzling is the case of a male patient of 60, operated upon for hydrocele, reported by Duboucher,¹³ to whom only 8 cc. of Evipal were given. This patient died 22 hours after operation with signs of uremia, *i.e.*, hypothermia, slow respiration and drowsiness, alternating with deep sleep. Since we know of no clinical or experimental cases in which renal lesions have been produced by Evipal, we agree with Menegaux and Sechelaye that we must attribute this death to nephritis and uremia rather than to Evipal. In the second case, reported by Hövelborn, death with respiratory arrest occurred four and one-half hours after operation. The report of this case is incomplete and no definite conclusions can be drawn. The third case was a man of 79, with a strangulated hernia, who died 12 hours postoperatively; immediately after injection this patient presented symptoms of apnea, which were relieved; here again it is difficult to be certain that this death was due to Evipal. On the other hand, however, there are a number of deaths which apparently are due to Evipal. The results we have obtained thus far do not permit us to accept the unfavorable opinion of Desplaas¹²; on the contrary, we feel strongly in favor of Evipal. However, the precautions in the technic of administration mentioned should be strictly observed if we are to be fair in our conclusions.

PREVENTION AND TREATMENT OF ACCIDENTS.—As stated previously the principal dangers in Evipal are toxic effects upon the cardiorespiratory centers, prolonged sleep and retarded or defective destruction of the anesthetic in the organism.

To avoid the first danger three preventive measures are necessary and sufficient: limitation of dosage to 10 cc. or less in one injection; second, slow injection, that is, a minimum time of one minute and 15 seconds for 10 cc., and third, the use of ephedrine immediately before the administration of Evipal, in order to counteract the initial drop of blood pressure. The other two dangers are connected with hepatic lesions and advanced degrees of sepsis; both contra-indicate the use of Evipal, because they hinder its oxidation and destruction in the liver.

Although we do not possess any real antidotes to the barbituric compounds, we have, however, a number of drugs with marked antagonistic properties to them. These are strychnine, cocaine, picrotoxin, coramine, icoral and alcohol.

Strychnine.—Haggard and Greenberg,¹⁷ and later, Duboucher¹³ and his collaborators, stated that strychnine was an antidote to barbituric acid. Dogs to which several times the lethal dose of barbituric had been given were resuscitated by using lethal doses of strychnine, and vice versa. But Chauchard⁶ has shown lately that this antagonistic action does not exist, in reality; but it is because of the powerful stimulating properties of strychnine upon the central nervous system and especially of the medullary centers, that this drug counteracts the depressive action of barbiturates upon these centers.

Cocaine.—Maloney²² has shown that cocaine is a strong antagonistic to barbiturates; however, although the former may prevent cocaine poisoning, the use of cocaine against toxic phenomena, due to barbiturates, is far from being regularly efficient.

Picrotoxin.—This alkaloid, which is a powerful stimulant of the medullary and spinal centers, seems to be the most active antagonist to the depressive action of barbiturates upon these centers. Maloney reported that experimentally he was always able to stimulate respiration and resuscitate animals poisoned with barbiturates, provided the heart was still beating. This substance appears to be the most efficient agent in cases of cardiorespiratory accidents due to intoxication by barbiturates.

Alcohol.—The use of 50 to 100 cc. of alcohol in 20 per cent solution intravenously seems to have a very favorable action against barbituric poisoning. These injections can be repeated if necessary (Carriere⁴).

Coramine—Escorine.—The advantage of coramine is that it is perhaps as efficient and much less toxic than strychnine (Carriere⁴). Large amounts of coramine should be used, usually 5 to 10 cc.; 40 to 50 cc. in one hour, intravenously, have been well tolerated. Escorine (Icoral, Bayer) is considered even more potent and efficient than coramine; Menegaux and Sechehayé have used it in cases of postoperative shock with gratifying results.

Thus it would seem that strychnine, coramine, escorine, alcohol and, of course, oxygen and carbon dioxide are powerful agents in stimulating respiration in barbituric poisoning. These drugs have the advantage of being easily administered. The most efficient antagonist of barbiturates seems, however, to be picrotoxin, the use of which is limited because of its toxicity.

CONCLUSIONS

(1) Evipal is a barbituric compound, which is almost completely (97 per cent) destroyed in the organism and is very rapidly eliminated. Its hypnotic action is practically instantaneous; the duration of anesthesia is short (10 to 30 minutes, with the administration of 1 Gm.).

(2) Rapid destruction and elimination of Evipal decreases, to the minimum, the dangers of toxic effects upon the respiratory and vasomotor centers. On the other hand, its action upon the laryngeal and bronchial reflexes is very slight.

(3) The above characteristics recommended this anesthetic agent in thoracic surgery and more particularly in thoracoplasties for pulmonary tuberculosis. One hundred consecutive cases of thoracoplasty are analyzed and the effects obtained are presented.

(4) In a general way the results were very favorable. Although the blood pressure presented a marked drop within one to three minutes and the respiration and pulse were accelerated, there were no untoward effects. Cough reflex and expectoration are rapidly restored after operation. Furthermore, intratracheal suction during operation by means of an intratracheal catheter was facilitated by this method of anesthesia.

(5) The physiologic, physiochemical and pharmacodynamic characteristics of Evipal are described.

(6) The antidotes and antagonistic substances are mentioned and the prevention and treatment of toxic complications are discussed.

(7) Only the effects of a single dose of Evipal, given intravenously, are reported.

(8) We have been greatly pleased with this anesthetic. Operative shock and postoperative complications have greatly decreased, the postoperative care was simplified and the patients have manifested a marked preference to this anesthesia over all other anesthetic methods used before. This last point is of great importance with patients who, usually, have to have repeated operations.

(9) Notwithstanding the obvious advantages of Evipal and our favorable results, it should not be forgotten that, like all barbiturates, Evipal is a toxic substance. A number of accidents have been reported.

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LOCAL PROPHYLACTIC USE OF ANTIGAS GANGRENE SERUM*

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AN APOLOGY is perhaps in order for the presentation of what may be designated as a preliminary communication, although the clinical report which forms its major part is based upon a considerable experience. It is hoped that the recitation of the observations which have been made relative to the prophylaxis rather than the actual treatment of gangrene resulting from wound infection may be considered of sufficient importance to warrant the use of this procedure.

Gas gangrene, so called, became of outstanding importance as a surgical problem during the World War and it was one of the causes of the high mortality. Because of its danger, treatment was begun before bacteriologic proof had been furnished.

Although there are other well known organisms which produce gas when they infect the tissues, the clostridium welchii or, as the French call it, *perfringens*, has been the one which has been principally studied. In order to prove the presence of exotoxin and the production of antitoxin, Bull and Pritchett⁵ infected the pectoral muscles of pigeons. One side was left untreated, and the other which had been equally infected they treated by injecting antiserum. The results were most impressive. The untreated infected side showed in a few hours the characteristic swelling, discoloration and crackling of this form of gangrene, the opposite muscle remaining absolutely normal.

You probably all know of the methods of therapy used during the War. Here we received the patient already infected and usually with fully developed gangrene. It was found that in spite of the local use of antiserum, that of Bull, Weinberg of the Pasteur Institute, and others, few if any favorable results were obtained, especially in the far advanced cases. In order to save a limb or perhaps a life it was necessary to extirpate the entire muscle even though there was visible contamination in only a small area. For example, I have seen more than once an entire quadriceps extensor muscle removed because of a small patch of apparently localized gas gangrene. Under this treatment many lives and limbs were saved but, naturally, with great resultant deformity and disability. It was pretty well recognized that although gas bubbles usually appeared in the areolar tissue, especially beneath the skin, the skin itself was not often the seat of spreading gangrene of this type, though other forms of foul necrosis do affect the skin. Still, the usual excision of diseased parts was performed. Of greatest importance would be a method for preventing the development of gangrene when infection is already present. And

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this was of particular consequence in wounds of parts which could not be treated by the radical surgery to which I have referred; for example, wounds of the chest wall. Here attempts were made by intravenous injections of Weinberg's serum but, so far as I could see, with little if any result.

On my return from the War I was anxious to make clinical experiments looking toward the prevention of the terrible gangrene of the chest wall, not always of the perfringens variety, after operations for suppuration of the lung. In looking over my records of the lobectomies of years ago, I found that even in the patients who recovered there had been a stage of spreading gangrene of the chest wall which gradually became limited after the casting off of sloughs.

In 1922, Professor Weinberg was kind enough to send me a generous supply of his antigas gangrene serum for intravenous use before operation as well as after. I used it in a number of cases but with no visible prophylactic effect. It then occurred to me that perhaps the local application of serum to the freshly incised thoracic wall immediately after operative evacuation of a putrid abscess of the lung might prove to be efficient.

In 1930, I began the systematic employment of this therapy. I am able to report that in nine operative cases of intrathoracic fetid suppurative disease, and one case of true gas gangrene of the leg, there was not a single visible postoperative anaerobic infection of the muscles or skin.

The usual surgical procedure in abscesses of the lung is to perform a preparatory operation whenever the infected region is not adherent to the parietal pleura, so as to minimize the danger of infecting the free pleural cavity. Whether in one or two stages, when the abscess is opened, drainage of some sort is carried out, either by tube, gauze, or both. In nearly all cases, infection of the muscular chest wall occurs, and often this causes more trouble than the mere drainage of the abscess. I determined to prevent this infection if possible by the local use of large quantities of mixed antigas gangrene serum. Having placed the drainage material into the abscess cavity, I completed the dressing by packing the entire wound of the chest wall from the abscess to the surface, with gauze saturated with the serum. This was placed in the form of a doughnut packing, leaving an opening for the deep drainage. At the early subsequent dressings this serum impregnated gauze was not disturbed and, when at the end of five or six days the doughnut was no longer adherent to the chest wall it was removed, leaving a perfectly clean, healing surface, with areolar septa sealed. From now on the abscess was treated in the manner best suited to the individual case but, in spite of the still present anaerobic organisms, no infection occurred in the chest wall. And even when other abscesses developed in the depths and were evacuated through the same opening, the fresh, virulent infection from these hitherto undrained pockets did not infect the healing, granulating wound of the thoracic wall. I have not seen any systemic effect ascribable to the serum such as serum sickness or urticaria, and the danger of this complication may probably be disregarded because no intravenous or other injections are made.

I have used the sera of several manufacturers, Lilly, Lederle, Sharp and

Dohme, Parke Davis, and others. There seems to be no difference in action; there are, however, some antitoxic sera made in high concentration. In only one instance have I employed the concentrated serum; in all the others I have used the ordinary product known commercially as antitoxic sera. Dr. Gregory Schwarzmann, of the Mount Sinai Hospital laboratory, suggested that an investigation of the antitoxic power of normal horse serum would be in order, saying that most horse sera had some antitoxic quality. He even advised that I should use as a control some cases in which ordinary horse serum sterilized by heat would be used in place of the gas gangrene serum, and he was kind enough to supply me with a quantity of this fluid. I made use of it in one case, a secondary operation. While there was no actual gangrene of the tissues there was infection with the appearance of the usual purulent exudate instead of the perfectly clean wound surface seen after the use of antitoxic serum.

The histories of two typical cases are presented, one of pulmonary abscess treated in this way and one of traumatic gas gangrene of a lower extremity. A brief résumé of other cases is also appended.

One objection which has been raised has to do with the price of the product. I maintain, however, that this may be counteracted by reduction in the time and expense of hospitalization.

CASE REPORTS

Case 1.—Mrs. Sophie H., aged 40, presented herself in May, 1933, with a well developed, foul pulmonary abscess following pneumonia and empyema. There was coughing and much fetid expectoration, and it is quite probable that the case had been originally a lung abscess, the empyema being secondary. She was well nourished and in good general condition. The abscess as determined roentgenologically was about the size of a small orange, and was at the level of the fifth rib posteriorly. She was operated upon at Mount Sinai Hospital on May 14, using local anesthesia throughout.

Procedure.—Because of the overdeveloped fat layer beneath the skin, it was not possible to palpate the ribs; but it was my intention to resect the fourth. An incision was made in the anterior axillary line, running downward. It was thought that general adhesions would be present, and this proved to be the case and allowed the opening of the abscess at once. After resecting the rib a large aspirating needle was passed into the lung where it encountered tough tissue nearly an inch away from the surface; it then entered an abscess cavity from which was drawn a small quantity of foul, thick material. The abscess was now opened with blunt dissecting scissors. There was fetid pus and the expulsion of a thick substance which looked much like gangrenous lung. The finger palpating within was unable to discover any secondary pockets but there were trabeculae probably containing vessels; the cavity was packed, because of the fear that a tube however soft might bring about erosion and hemorrhage. A thick packing of gauze soaked with antigas gangrene serum covered the entire wound through the chest wall. There were no sutures.

Six days after the operation the packings within the abscess cavity were replaced by a soft black rubber tube. On removing the packing from the chest wall not the slightest sign of infection was present and this part of the wound healed with great rapidity. The patient was discharged on June 8, 29 days later, convalescent and with no sign of pulmonary suppuration. (Case 5 in Résumé.)

Case 2.—(Case 7 in Résumé.) Mrs. Dora F., whom I saw in February, 1934, with Dr. I. S. Tunick. Six days before in an automobile accident she received a fracture of the

right fibula five and one-half inches above the ankle, with almost no displacement. There was, however, a severe, deep laceration of the leg below the knee with a few neighboring blebs. The patient was also suffering from multiple contusions and from a laceration of the scalp. The wounds had been sutured without drainage. Antitetanus serum had been administered and, the day following the accident, antiperfringens serum as well.

Five days after the injury, Doctor Tunick saw the patient at the Hospital for Joint Diseases, and immediately recognized the characteristic crepitation of gas infection below the wound. She had a temperature of 101.6°F. He at once removed the sutures, and examination of the infected fluid revealed a rapidly growing pure culture of perfringens. The wound was about five inches in length, and there was an area of necrotic and infected skin adjacent to it. Sagittal incisions were made by him at each end of the wound to improve drainage. The following day I saw the patient. Although the general condition was good, her face was pale, with a slightly yellow tinge. Characteristic foul odor was present, and crepitation was distinct and extended to a point four to five inches below the laceration. The foot was somewhat swollen but did not appear to be infected. There was an area about five inches long and three inches wide on the outer surface of the mid thigh which was discolored, so that a tourniquet was not applied.

The lacerated and gangrenous skin was completely excised, as well as that surrounding the incision which had been made previously. Complete débridement was performed down to what looked like healthy muscle, so that at the conclusion of the operation apparently only normal tissues were visible. Had I been called upon to treat a case of this kind during the War, the proper procedure would have been to extirpate all the muscles which had been lacerated. Here, however, only manifestly infected muscle was removed. A packing of several layers of gauze soaked with polyvalent antigas gangrene serum of the concentrated type was applied, and placed in contact with all visible parts of the wound. Upon this was laid a piece of oiled silk, and the leg was then encased in thick elastic gauze pads pinned in place—no bandages were applied. There was excellent reaction and next day the temperature was nearly normal.

Seventy-two hours after the operation the wound was exposed. There was no redness, no sign of progressive inflammation, and the subsequent course of healing was most satisfactory.

In all the references consulted there were only two investigators who had made experiments with sterile horse serum, the first nearly 35 years ago. Raymond Petit¹⁶ made some important experiments at the request of Metchnikoff. It may still prove that certain horse sera are inherently antagonistic to the microbes responsible for traumatic gangrene, although, as Schwarzmann has stated, the sera vary greatly in potency. Petit made experiments in prophylaxis in the peritoneum, in the uterus (in puerperal infections), in purulent pleurisy, in phlegmons, and in other wounds healing by secondary intention. The horse serum which he used had been sterilized by heat. The presence of these normal sera he found produced polynucleosis, the cells becoming phagocytic. He employed horse serum because it is ordinarily less toxic than the bovine. It was heated in a water bath for two hours for three consecutive days at a temperature of 194° F. in order to get rid of the alexin. Petit's theory was that the bactericidal quality of the horse serum was secondary, and that the real antiseptic effect was that produced by the induced phagocytosis. He even antedated my observations in regard to the use of serum poured into the opened pleura, employing these instillations every day for several days. Use was also made of powdered serum which he introduced into septic uteri, and in phlegmons by means of gauze impregnated with the

powder. There is no mention made, however, of its use in the *prophylaxis* of combating or preventing the gangrenous infection of tissues adjacent to the infected region, for instance the chest wall; and it is in this connection that I have made my principal clinical experiments. Kling reported experiences with infection of the extremities by the *clostridium aerogenes-capsulatum*. He made intravenous injections of horse serum in two cases with apparent detoxication and excellent results. This has little to do with the prophylaxis, which is the subject of the present article.

In the cases mentioned below, the antigas gangrene serum was employed with notable success. In no case was there gangrenous or other marked infection of the chest wall:

RÉSUMÉ OF CASES TREATED

Case 1.²⁰—1930.—Ignatius C., aged 22, revision of lobectomy. Antigas gangrene gauze was used in this case, but was not specifically mentioned in the published report.

Case 2.—1931.—Dan B., aged 15, lobectomy for old chronic suppuration.

Case 3.—1931.—Anna C., aged 32, foul pulmonary abscess. Several operations. Antigas gangrene serum used twice with no infection of chest wall.

Case 4.—1931.—Sam K., aged 41, lobectomy in two stages. Serum used each time. Excellent effect. No sloughing.

Case 5.²¹—1931.—Sophie H., aged 40, already reported in this paper.

Case 6.—1933.—Benjamin M., carcinoma of left lower bronchus, with bronchiectatic suppuration, left lower lobe. Extirpation of lobe. Case reported in *Am. Jour. Surg.*, New Series, vol. 27, No. 1, p. 50, January, 1935.

Case 7.—1934.—Dora F., case reported in this paper.

Case 8.—1934.—Louis G., foul abscess of lung with pulmonary gangrene. No visible infection of chest wall.

Case 9.—1934.—Joan R., aged 3. Thoracic fistula with foreign body. Extremely foul discharge from sinus of chest wall. Patient septic. Repeated instillation of serum removed all odor in a few days; then operation. Serum used. No chest wall infection.

Case 10.²²—1935.—H. S., male, aged 50. Fetid lung abscess. Clean pleura unavoidably opened, and antigas gangrene serum poured in through a second wound which had been made for drainage. No acute infection, no odor, clear serum for a number of days, then opalescent. Antigas gangrene serum used during two procedures.

SUMMARY

(1) Prophylactic treatment of healthy structures wounded during operations upon tissues the seat of gas gangrene, is presented.

(2) This has been accomplished by packing the healthy portions of the wound with material impregnated with antigas gangrene serum.

(3) A brief résumé of ten cases is given.

CONCLUSION

Experience with this form of prophylaxis has convinced the writer of its value.*

* In presenting this subject I have made use of the term gas gangrene when the qualifying word might better have been omitted, although one of the case histories was that of traumatic gangrene which proved to be a perfringens infection. In the discussion it was naturally but erroneously assumed that the paper dealt exclusively with gas gangrene. What is really meant is any gangrenous, sloughing, fetid infection of the chest wall.

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DISCUSSION.—DR. FRANK H. LAHEY (Boston) said he would be glad to speak about gas bacillus infections in chest wounds if there had been any, but they had had none. Doctor Overholt, who is in charge of chest surgery, had performed quite a number of lobectomies for bronchiectasis but he felt sure there had been no case in which there was a gas bacillus infection. He was particularly interested, however, in personal experiences with gas bacillus infections following dilatation of the sphincter of Oddi in patients with common duct stones. For some time dilatation of the sphincter of Oddi has been employed in the Clinic by means of what are called Bâkes dilators, this method having been called to his attention by Dr. Arthur W. Allen and which had proved to be quite a useful procedure. The dilators are graduated in size up to 11 Mm. in diameter and when passed through the sphincter leave the opening of the common duct into the duodenum so dilated that any detritus or small stones overlooked in the removal of common duct stones will be washed into the duodenum by the flow of bile. The common and hepatic ducts were opened and explored for stones in the course of gallstone operations in 531 cases. Previous to the employment of these dilators, there had never been a case of gas bacillus infection of the liver in the gallstone cases. Since their employment, however, there have been two fatal gas bacillus infections of the liver, both proven by autopsy and doubtless due to *C. welchii* ascending the ducts from the duodenum through the dilated sphincter. Doctor Lahey said he was mentioning these two fatalities not to condemn the dilators, because they are very useful instruments, but to warn surgeons concerning the possibility of this complication and to call attention to the fact that there must be a real danger to overdilatation of the sphincter of Oddi. He con-

cluded that he had had little experience with *C. welchii* infections elsewhere because so large a part of the surgery in the Clinic is of the deliberate type and so little of it traumatic.

DR. FRANK L. MELENEY (New York) said that he had been very much interested in the bacteriology of lung abscesses because he has thought that they are very frequently symbiotic infection. It is rather difficult to make a complete bacteriologic analysis of the contents of a lung abscess. If sputum is taken and examined, it is complicated because the pus from the abscess is mixed with all the mouth organisms. But if a culture is taken directly from the lung abscess at operation one may get a fairly good idea of the organisms existing there, some of which may be factors in the infection itself and others just casual contaminants. In looking for gas gangrene organisms 14 cases have been studied carefully and only one case was found in which a gas gangrene organism was present and that was *C. welchii*. Doctor Cohen has reported 16 cases from Mt. Sinai Hospital but Doctor Meleney did not know whether or not these included any of Doctor Lilienthal's patients. However, in no case did he find any of the gas gangrene organisms. Doctor Varney, in a larger series of 27 cases, found no gas gangrene organisms in lung abscesses. *C. welchii* pneumonia does occur, but gas gangrene organisms in lung abscess seem to be particularly rare. If it is assumed that they are frequently present and these cases are treated with antigas gangrene serum, the situation will not quite be met. Doctor Meleney asked Doctor Lilienthal if he formerly had any proven cases of gas gangrene of the chest wall following operation for lung abscess. There are polyvalent antitoxic sera put out by several commercial firms, which specifically neutralize the toxins of the gas gangrene organism. These sera should be used in the active treatment of gas gangrene cases or may properly be used as a prophylactic in situations in which gas gangrene is likely to arise; but where gas gangrene organisms are very unlikely to occur Doctor Meleney did not feel that the general use of antitoxin is indicated. His laboratory experience with *C. welchii* vaccine had been very disappointing in attempts to develop an immunity and agreed, with Doctor Schwartzmann, that horse serum does have an inhibiting action on a number of organisms. The organisms that occur in lung abscesses are largely the anaerobic streptococci, micro-aerophilic streptococci, spirochaetes and fusiform bacilli. The spirochaetes and the fusiform bacilli are not particularly virulent in pure culture but, in association with streptococci, do produce, or at least are found in, the worst cases of lung abscess. To combat those organisms something more is needed than antigas gangrene serum. The best agent in Doctor Meleney's experience was zinc peroxide, which Doctor Moore had recently used in seven cases at the Presbyterian Hospital. This will usually be found effective not only in control of the gas gangrene organisms but also of the anaerobic streptococci, micro-aerophilic streptococci, spirochaetes and the fusiform bacilli.

DR. HOWARD LILIENTHAL expressed his surprise to hear, after having had considerable experience with chest surgery, that gas gangrene in these cases is so very unusual in civil life. He agreed that it is perhaps not quite accurate to use the word "gas gangrene" when really he had meant any gangrenous, sloughing, fetid infection of the chest wall. It can hardly be considered entirely a coincidence, that when formerly he saw sloughing infection of the wall of the chest in practically every case in which a foul lung abscess had been evacuated surgically, and after nearly every case of lobectomy for suppurative bronchiectasis, he can now present ten consecutive cases without any sign of gangrene. By employing, as described, the antigas gangrene serum, there has been no sloughing or visible infection of the chest wall. His work, he stated, has been in a measure empirical.

ACUTE INTESTINAL OBSTRUCTION BY THE PERSIMMON PHYTOBEZOAR

REPORT OF TWO CASES

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THE term bezoar, from the Arabian bazahr, badizahr, and the Persian pad-zahr, pad (protecting) + zahr (poison), meaning counter poison or antidote, denotes any of the various concretions found chiefly in the alimentary organs of certain ruminants. Bezoars were formerly supposed to have remarkable medicinal properties, especially as antidotes to poison. The kind most prized was the oriental bezoar, composed principally of resinous organic matter arranged in concentric layers about some hard foreign nucleus, and found in the bezoar goat and gazelle. The western or occidental bezoar, found in the Peruvian llama, consists chiefly of calcium phosphate, while the German bezoar, from the gemsbok, is composed of interlacing fibers or hairs and organic cementing material.

In man, three types of bezoars have been described: the trichobezoar, or hair ball; the phytobezoar, or vegetable fiber ball; and the shellac bezoar composed of concretions of shellac. The trichobezoar is the most common type and occurs in the stomachs of persons addicted to the chewing and swallowing of hair, while the phytobezoar is the next most frequent variety. Maes,¹ in 1928, was able to collect 116 cases of trichobezoar and 23 cases of phytobezoar from the literature. In Germany, a few instances of shellac bezoar have been reported. These curious masses have been found in the stomachs of patients who had drunk shellac for its alcoholic content, the gummy part of the mixture having been precipitated with the formation of a shellac bolus by the addition of water to the original solution.

Quain,² in 1854, described the first case of phytobezoar in man. The mass, composed of cocoanut fibers, was found postmortem in the stomach of a young insane patient, and had caused death by perforation on the lesser curvature of the stomach. Outten,³ in 1894, was the first to record the occurrence of a persimmon bezoar, and it was not until 28 years afterward that Peple,⁴ in 1922, mentioned a second instance. Hart,⁵ in 1923, reported eight cases of phytobezoar, six of which were persimmon bezoars; one was of celery fibers, and one of prune and raisin skins. Adams,⁶ in 1925, recorded the case of a Chinaman who, at operation, presented a cast of the stomach formed of pumpkin pulp. Bryan's⁷ case was that of a man, aged 55, who suffered from abdominal distress and intermittent diarrhea for three years. At operation a soft mass was removed from the stomach consisting of celery fibers and prune and raisin skins.

Of the phytobezoars the persimmon bezoar is by far the most common,

and, since Hart's paper, the number of reported cases has steadily been added to (Upson,⁸ Porter and McKinney,⁹ Larimore,¹⁰ two cases, Garrett,¹¹ David,¹² Maes,¹ Balfour and Good,¹³ Potter,³⁵ Camp,¹⁴ Podlasky,³³ subsequently reported by Droegemueller,¹⁵ Lobingier,¹⁶ Cole,³¹ four cases, Pollock,¹⁷ Wyatt,³² Schulze,¹⁸ Smith,³⁴ two cases, Crossan,¹⁹ Durrance,³⁶ six cases (five collected from various sources), Henschen³⁷).

Phytobezoars rarely cause intestinal obstruction. There are seven reported cases in which these masses have produced acute small bowel occlusion. Of the 37 reported cases of persimmon bezoars, in only four instances has the bolus been found in the intestinal canal. An additional case, probably of a persimmon bezoar, reported by Downing,²⁰ brings the number of proven and probable obstructing persimmon bezoars to five. In all of these cases, acute obstruction had necessitated surgical intervention. In addition, Wyatt³⁸ saw one case and O'Bannon³⁰ saw two cases of small bowel obstruction from persimmon bezoars. Wyatt's case was not reported, and O'Bannon, in discussing Durrance's paper, only mentions the fact.

Simpson,²¹ in 1923, cited the case of a girl of 16 who was operated upon six days after the development of acute intestinal obstruction. A preoperative diagnosis of small bowel obstruction from a band or volvulus was made. At operation, a mass four and one-half inches in length and two and three-quarter inches in breadth was removed from the ileum, 16 inches from the ileocecal valve. The obstructing body was stony hard and composed of heather roots and twigs, which the patient had been in the habit of chewing. The patient made an uneventful convalescence.

In the case of Dr. Chas. L. Patton, of Springfield, Ill., (Hart's⁵ third case), the patient, a male, aged 38 years, had eaten of chicken, potatoes, cheese, stewed cranberries, and a large amount of celery. The following day he developed a sensation of fulness and pain in the abdomen. These symptoms became intermittent, occurred one to two hours after meals, and were relieved by powders. The patient later developed intermittent obstruction and two and one-half months afterward an exploratory operation was performed. A mass, two by three-quarters by one-half inches, composed of celery, was removed from the ileum six inches above the ileocecal valve. A second mass, formed of similar material, and measuring three by two and one-half by two inches, was removed from the stomach. The patient made a complete recovery.

The case of Dr. Carl Davis, of Chicago (Hart's⁵ seventh case), was of a male, aged 55, who had had a gastric ulcer for many years. On one occasion he ate many persimmons and subsequently developed a sensation of generalized ill feeling associated with epigastric pain which subsided in five or six days. Eighteen months afterwards a gastro-enterostomy was performed because of several similar attacks. A preoperative roentgenologic study had revealed a gastric ulcer. At operation no exploration of the stomach had been carried out. Eight months after the performance of the gastro-enterostomy, the patient developed acute intestinal obstruction. At operation a

persimmon bezoar, measuring 7.5 by 5 cm., was found impacted in the jejunum. Enterotomy was performed and the patient made a complete recovery.

Downing,²⁰ in 1926, reported the case of a female, aged 21, who developed symptoms of acute intestinal obstruction. Twenty-nine hours after the onset of symptoms laparotomy was performed. A rough, black mass measuring 2 cm. in diameter had produced a perforation of the small bowel 30 inches from the cecum. There was an associated acute peritonitis. Enterotomy was performed and the patient recovered completely. The inspissated material dried on exposure to the air and in every way conformed to the physical characters of a persimmon bolus. Its origin, however, was not definitely determined and no mention of the patient having ingested persimmons was given in the report.

Lobingier,¹⁶ in 1930, reported the case of a female, aged 33, who, three days before, had eaten several Japanese persimmons. The patient developed nausea and abdominal cramps. A diagnosis of obstruction was made. At operation a mass was found arrested in the midjejunum. There was marked distension of the bowel. Enterotomy was performed, using a linear incision. The removed specimen consisted of persimmon hulls and measured 4 by 3 by 3 cm. The patient made an uneventful recovery.

Cole,³¹ in 1931, mentioned two brothers, aged 75 and 66, respectively, operated on by Dr. Frank G. Nifong, of Columbia, Mo. In Doctor Nifong's first case, the patient had had abdominal pain for six days. A preoperative diagnosis of obstruction was made and at operation a mass, the size of a walnut, composed of persimmon seeds, was found about 24 inches from the ileocecal valve. The first patient's brother, operated on three years later, had developed severe abdominal pain, associated with vomiting, two days before. At operation, a large mass composed of persimmon seeds and pulp was found in the ileum. The subsequent course of these patients is not given in the report.

During the past five years we have had the opportunity to observe two patients who developed acute small bowel obstruction as the result of impaction of persimmon bezoars in the ileum.

CASE I.—Mrs. C. B. F., a white female, aged 50 years, was admitted to the hospital October 23, 1930, complaining of nausea, vomiting, and diffuse intermittent abdominal pains of about 43 hours' duration.

She had been seen by one of us (R. L. H.) in 1926. At that time she complained of gas, discomfort, and crawling sensations in the left side of the abdomen. These symptoms had appeared about two years before, had slowly progressed in intensity, and at times were especially marked after meals. Examination revealed no evidence of organic disease and a diagnosis of probable neurosis was made. These symptoms, however, did not improve, and, in October, 1926, a diagnosis of appendicitis was made elsewhere. A barium meal, at that time, revealed no abnormality of the gastro-intestinal tract. In May, 1927, the patient consulted physicians of the Mayo Clinic who were unable to find any definite evidence of organic disease. Notwithstanding these negative findings, the symptoms continued to increase in severity. She suffered with

much gas, discomfort after meals, and abdominal distension. However, to the present day, the patient denies ever having had any stomach trouble or true abdominal pain.

On the evening of October 21, 1930, after having eaten chili for supper, the patient became nauseated, vomited, and developed intermittent, colicky, abdominal pains. The following morning a diagnosis of probable acute intestinal obstruction was made. However, due to unavoidable circumstances, operation was, contrary to our advice, deferred until the following evening. At the time of admission to the hospital the patient presented evidences of a rather marked obstruction with beginning peritonitis. There was slight diffuse tenderness and rather marked abdominal distension. The leukocyte count was 10,600 with 85 per cent neutrophils. A barium enema revealed a practically normal large bowel. Laparotomy was performed about 48 hours after the attack began. Under ether anesthesia, the abdomen was opened through a liberal right rectus incision. The loops of small intestine were markedly distended, inflamed, and exhibited many small areas of ecchymosis. There was considerable free fluid in the peritoneal cavity. The appendix was examined and found perfectly normal. The terminal ileum was collapsed and on tracing the gut upward a hard mass the size of a guinea egg was found impacted about 18 inches from the ileocecal valve. Transverse enterotomy was

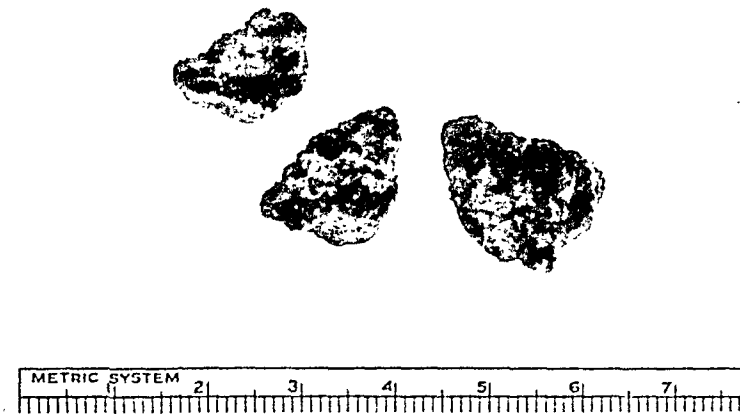


FIG. 1.—Major portions of persimmon bezoar in Case I, which have shrunk to about one-third of their original size.

performed over the mass which was so firmly impacted and closely applied to the intestinal wall that it was of necessity broken up and removed in fragments with the scalpel handle. The gut was sutured with two rows of catgut and covered with omentum. Drainage was instituted because of the associated peritonitis. The patient had a stormy convalescence. Large quantities of saline and glucose were administered intravenously and subcutaneously, and it was necessary to use continuous gastric drainage by means of the nasal catheter. Four days after operation her condition was markedly improved and she was dismissed from the hospital November 11, 1930, 19 days after admission.

The removed particles consisted of tightly compressed persimmon pulp and hulls. The reconstructed bolus was dark brown in color except for a few outer flakes of skins which had retained their orange-red tint. It was roughened on its external surface, and measured approximately 6 by 4 by 4 cm. On exposure to the air the fragments dried and shrank to about one-third their original size (Fig. 1).

Subsequent to the operation, the patient has been entirely free from the annoying symptoms. No doubt all of her previous trouble had been produced by the bezoar. How long it had been present and where it was formed is purely problematic. However, the presence of bits of orange-red skins on the external surface of the bolus indicates that at least this portion had been of comparatively recent origin.

On further questioning, the patient stated that all of her life she had been very fond of wild persimmons. In childhood she had partaken of them on numerous oc-

casions. She remembered vividly of having eaten, on one occasion, in the fall of 1915, large quantities of this fruit. Almost every fall thereafter friends would send her persimmons, and she recalls having eaten them from a neighbor's tree in the late years of her illness. The patient, however, stated that persimmons had never made her sick and that she had never been able to associate them, in any way, with her symptoms.

CASE II.—H. B., a policeman, aged 34, had, for two years, experienced attacks of abdominal pain lasting from a few minutes to an hour or more. These attacks, at first placed at intervals of a week or longer, had gradually become more frequent.

On the morning of December 25, 1934, he was taken with a severe seizure. He took an enema and passed a portion of material about the size of half an egg. The intermittent abdominal pains continued, and he was admitted to the hospital shortly afterward. Examination, at that time, revealed nothing of significance. During the day the leukocyte count, taken on three occasions, was 9,200, 11,000, and 10,000. The symptoms became less severe; however, during the night, he vomited on one occasion. The following morning the pains again increased in frequency. There was much belching and the patient vomited twice. The abdomen was slightly distended and a point of tenderness just below and to the right of the umbilicus was elicited by pressure over the left side of the abdomen. The leukocyte count was 19,200. A diagnosis of acute intestinal obstruction was made.

Twenty-eight hours after the onset of the attack the abdomen was opened, under ether anesthesia, through a right rectus incision. Some loops of small intestine were distended and red, while others were collapsed. There was little free fluid in the peritoneal cavity. The appendix was found normal and was not disturbed. On tracing the collapsed ileum upward a firm mass the size of an egg was found impacted in the ileum about five feet from the ileocecal valve. The gut above was markedly distended. The obstructing body could be moved up and down in the intestine for only a short distance. Transverse enterotomy was performed, the foreign body removed, and the opening closed with two rows of catgut. The abdomen was closed without drainage.

The patient made an uneventful recovery and was dismissed from the hospital eight days after operation. He has had no further trouble.

The obstructing body (Fig. 2) composed of persimmon hulls and pulp, was roughened, dark brown in color, showed a few red skins on its external surface, measured 5 by 3 by 2.5 cm., and weighed 17.7 Gm.

The patient had eaten persimmons for many years, but only on a few occasions had he taken many at a time. During the fall of 1932 and 1933 he ate much of the fruit. On December 9, 1934, while hunting, he ingested many persimmons. That afternoon he ate chili and during the night developed nausea which lasted for two or three days. He attributed this sickness to the chili, for two other people who had eaten the chili with him also became ill. He had never eaten persimmons before that made him sick. On December 16, nine days before the acute attack began, he again ate a considerable quantity of persimmons while hunting.

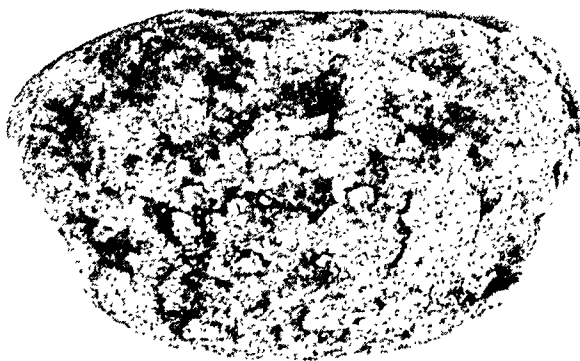


FIG. 2.—Persimmon bezoar in Case II. Photograph taken soon after removal.

Food, chiefly fruit, has occasionally produced intestinal obstruction. In nearly all the instances the patients failed to masticate the food properly, either due to haste or because of deficient dentition.

Willmoth,²² in 1921, recorded four instances of obstruction of the intestinal tract from ingested food; one from potatoes, two from grape hulls and seeds, and one from popcorn. All of these patients recovered following repeated enemas, and in none was operation performed. Alexander,²³ in 1924, reported the case of a man who presented an obstruction a few inches above the ileocecal valve due to a large fig which had been swallowed whole. Another of Alexander's patients suffered from a very acute obstruction of the jejunum produced by a large raisin which had been swallowed intact in the course of eating raisin dumpling. Bryan,⁷ in 1926, cited the case of H. O. Koefod, of Santa Barbara, Calif., of a boy, aged six years, who died from intestinal obstruction produced by a large bolus of coarse vegetables in the lower ileum. Chalmers,²⁴ in 1927, reported a second case of a whole fig impacted in the ileum of an edentulous man. Ackman,²⁵ in 1929, cited the case of a boy of seven years of age who at operation presented a pint of cherries impacted in the lower ileum. Wardill²⁶ and Gage²⁷ have seen small bowel obstruction from pieces of potato.

Elliot,²⁸ in 1932, collected, from the literature, 39 cases of intestinal obstruction caused by food, none of which was produced by persimmons. In his case, ileus was produced by a mass of orange pulp and seeds impacted in the lower ileum. Block,²⁹ in 1933, reported an additional case of obstruction of the lower ileum from orange pulp in an edentulous person. In both Elliot's and Block's cases the obstructing material had formed soft bulky masses and the obstruction came on soon after ingesting the material. It seems desirable not to classify the cases of Koefod,⁴¹ Elliot,²⁸ and Block²⁹ as phytobezoars, but as impactions of food, therefore they have not been included in the cited reports of bezoar obstructions.

Mushrooms, beans, oats, corn, poppy seed, sauerkraut, gooseberries, and bran have occasionally produced obstruction (Elliot).

Although persimmon bezoars are much more frequently observed than the number of reported cases would indicate, yet obstruction to the bowel by them is indeed rarely encountered. It seems evident that most persimmon bezoars of any size are formed in the stomach, and that they are usually produced after eating the fruit on an empty viscus, the acid coagulating the pulp and juice which contain a high concentration of pectin and gum (14.1 per cent³⁰). Whether persimmon bezoars are at times formed in the intestinal tract seems less certain.

In the two cases reported, the patients had for some time suffered with vague abdominal symptoms undoubtedly due to bezoars. In our first case there is no history of an acute gastric upset, following the ingestion of persimmons, so frequently obtained from patients with gastric bezoars. Probably the bezoar had been present in the intestinal canal for many years, for fluoroscopic examination of the stomach, made in 1926, showed no evidence

of a foreign body. Contrary to the usual teaching that bezoars are formed at one sitting, the presence of red skins on the external surface of the bezoar in Case I strongly indicates that the original bolus had been added to. The patient in Case II gave the characteristic history of eating persimmons while hunting and developing an acute stomach upset. This patient probably had had another bezoar of long standing which he expelled after taking an enema on the morning of his last attack. This explains the long history of abdominal colic, the presence of a relatively recent bezoar producing the obstruction, and the acute stomach upset 12 days before.

It is interesting to note in the five cited cases of intestinal obstruction from phytobezoars, in which the postoperative course is given, and in the two additional cases which we have reported, that all of the patients recovered. In both our cases a diagnosis of acute small bowel obstruction was made pre-operatively; however, the exact nature of the obstruction was not known until afterward. So many people in this part of the country give a history of eating persimmons that this is of little aid in making a diagnosis of persimmon bezoar obstruction. Furthermore, in Case I, it was very difficult to obtain a history of the patient having eaten persimmons, even after the true nature of her condition had been demonstrated.

The occasional occurrence of obstruction in these cases has suggested to Potter⁴⁰ the inadvisability of manipulation and breaking down of a stomach bezoar as a method of treatment.

In both of our cases the bezoars were formed of the pulp and hulls of the wild Texas persimmon (*diospyros texana*).

SUMMARY

Of the various types of phytobezoars, the persimmon bezoar is the most common.

Persimmon bezoars are usually found in the stomach; however, in exceptional instances, they may pass into or be formed in the intestinal canal and produce acute small bowel obstruction.

Persimmon bezoars constitute one of the least frequently encountered causes of obstruction by food.

The prognosis in cases of phytobezoar obstruction seems to be very good, for, in the five reported cases of acute small bowel occlusion by these masses, in which the subsequent course is given, and in the two additional instances of persimmon bezoar obstruction which have been given, all of the patients recovered following enterotomy and removal of the obstructing bolus.

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TRANSVERSE INCISION IN THE UPPER ABDOMEN

ITS ANATOMIC AND PHYSIOLOGIC ADVANTAGES

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THE recent history of the transverse incision, both infra-umbilical and supra-umbilical, has been repeatedly reviewed. Mention will be made only of those connected preeminently with the first use of the incision. The transverse abdominal incision is not a recent procedure. In 1798, a cesarean section was performed through a transverse opening. In our own day, Rapan, in 1894, Kustner,¹⁰ in 1896, Hartman, in 1900, and Pfannenstiel,²⁰ in 1900, employed new types of transverse incisions in the lower abdomen. Their success, no doubt, inspired more extensive experiment with the incision and its use in upper abdominal surgery.

Langenbuch,¹¹ in 1882, removed a gallbladder through an L-shaped incision, and was apparently the first to cut the upper abdominal wall across. Maylard,¹³ in 1898, is accredited with performing a stomach operation through the first transverse incision piercing the entire thickness of the wall. In Europe, among those who have had noteworthy results from a transverse incision of original design are Sprengel,³⁰ Perthes,¹⁰ Bakes,¹ and König.⁹ In America, Moschcowitz¹⁸ sponsored a somewhat radical procedure, and C. U. Collins,⁴ Souther,²⁹ McArthur,¹⁴ Quain,²² Sloan,²⁷ Mason,¹² Singleton,^{25, 26} the Bartletts,² Schwyzer,²⁴ and others, have offered modifications. The method as developed by all these operators has differed in some degree, more or less, from those presented previously.

The opinion that the transverse incision, in a certain group of cases, is superior in practically every respect to other types seems to be rapidly gaining ground. Some well known surgeons still cling to the vertical opening, but the results of the transverse incision have been so gratifying in the experience of many of us that we are inclined to wonder if the advocates of the former have given the latter a fair trial.

The transverse incision, like other operative procedures, has gone through a process of evolution, as it were. The pioneers cut across only the superficial layers of the abdominal wall, merely for the cosmetic effect, or only a small part of the incision was made transversely, the major portion having been longitudinal. Then, a few surgeons curved the incision to correspond to the contour of the costal arch. Others combined the straight transverse with a vertical, an oblique, or a curved line, according to the individual conception of the most suitable opening for a particular operation. All have tried to find a technic which would preclude objections and approximate as nearly as possible the anatomic ideal. Various defects, however, have been found in each method in turn, but, almost without exception, the surgeon

who has used the transverse incision to an appreciable extent has been pleased with the results, whatever the technic.

A short discussion of some of the more modern and more popular types of transverse incision will be prefaced briefly by a description of the anatomy of the abdominal wall. The supportive structures of the abdominal wall consist of three lateral and two median muscles, their respective sheaths, and the linea alba. The lateral muscles, the external and internal oblique and the transversalis, are long and flat, with fibers running the direction of their length. Their aponeurotic continuations separate around the rectus muscles

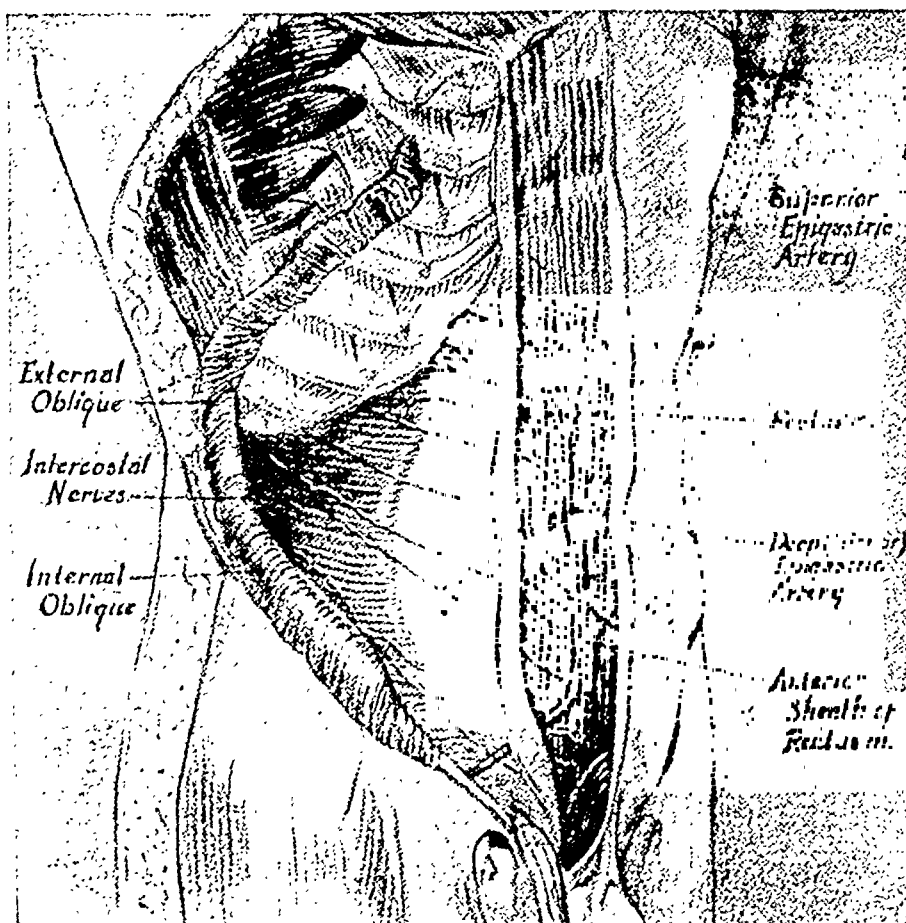


FIG. 1.—Anatomic drawing showing the position of nerves and blood vessels in the abdominal wall. (By courtesy of Dr. A. O. Singleton.)

to join again at the midline in a thick, single layer structure, the linea alba. These muscle sheaths play an essential part in preserving the strength and function of the wall.

The rectus muscles are divided into segments by the linea transversae, which attach the muscles to the anterior aponeuroses. As the linea transversae seldom extend through more than half the thickness of the muscles, on their posterior sides the muscles are less firmly attached to the posterior aponeuroses. Apparently, this division of the muscles into segments provides intermediate points for force and resistance, permitting varying degrees of abdominal tension in the different portions of the abdomen.

The blood vessels of the midportion of the abdominal wall run, for the

most part, longitudinally. The more important, the superior and inferior epigastric arteries, are found on the posterior aponeuroses adjacent to the recti. To the side, their course becomes transverse, corresponding to that of the intercostal nerves. Severance of these vessels presents no especial problem in closing a transverse incision.

The abdominal muscles derive their nerve supply from the seventh, eighth, ninth, tenth, and eleventh intercostal nerves, the subcostal nerve, the inguinal, and the hypogastric branches of the iliohypogastric nerve. Their direction conforms to the lines of the muscle fibers and extends forward and inward. Vertical incision, therefore, necessarily cuts one or more of the nerve trunks, producing atrophy and weakening of the muscles and, in some cases, subsequent postoperative hernia.

In devising a new type of transverse incision or in modifying one already known, each surgeon has taken into consideration these salient features of the wall structure. Their views as to the least harmful and most effective approach, however, have differed somewhat. The points of difference are worthy of discussion.

Moschcowitz, following the plan of Sprengel and Bakes, and making one incision entirely through the abdominal wall, severed one or both recti completely, depending upon the operation to be done. He sutured them to the anterior sheaths to prevent retraction, permit better end-to-end closure, and to insure hemostasis. This, he stated, gave excellent exposure and obviated the necessity for bulky packings. He did not see any harmful effects of cutting the muscles in 67 patients observed from a few months to almost six years postoperatively, and believed the firmly healed peritoneum and aponeuroses, and the small, firm cicatrix at the union of the muscles, with their unimpaired nutrition and nerve supply, offer sufficient guarantee against the development of hernia.

Critics of this method say the scar is likely to become weakened from prolonged stretching, atrophy of the recti adjacent to the incision is a possibility, and there is danger of postoperative hernia, even after the lapse of years. It is said, also, that, since the rectus muscles hold stitches badly, "dead space" may be left in the line of incision, giving rise to the development of an hematoma and infection.

Quain has performed 500 operations on the biliary tract and stomach through a straight transverse incision involving partial severance of the rectus muscles. He reports one postoperative hernia, which occurred as a result of extensive drainage of an empyema of the gallbladder, and which was cured spontaneously. He also had one rupture of a wound in a patient with a complicating bronchitis. There was no loss of life consequent upon the incision. Since his procedure is similar to that of Moschcowitz, it has been open to practically the same criticism.

Mason joins two short vertical incisions, one to the left and above the umbilicus, the other to the right and below the umbilicus, by a transverse incision through the linea alba. Both rectus muscles are retracted laterally,

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and the transverse portion of the incision is overlapped when closed. This offers access to a large portion of the abdomen and is suitable for a number of surgical procedures. His idea of preventing hernia by short incisions is a good one, but by this technic one is confronted with the doubtful outcome of closure of the wall at two right angles.

Sloan presented an innovation in upper abdominal incisions when he advocated a median vertical opening down to the fascia. The skin and fat were widely dissected and a paramedian vertical incision was then made through the anterior sheaths of both recti. The muscles were retracted laterally and

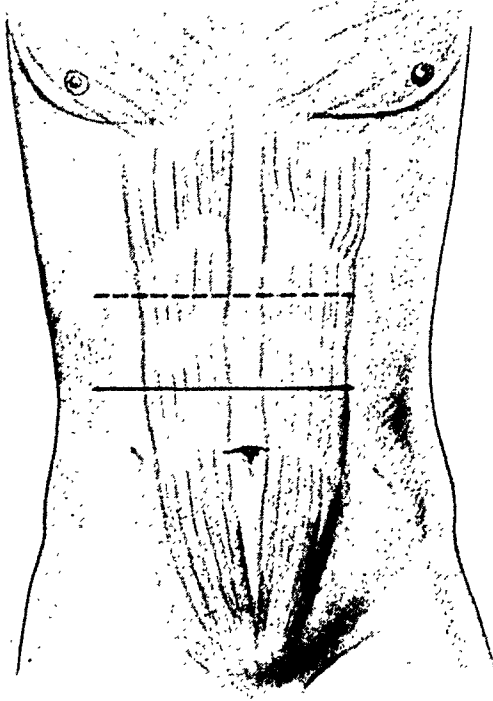


FIG. 2.—Showing that the incision may be made at various levels, according to the width of the costal angle.

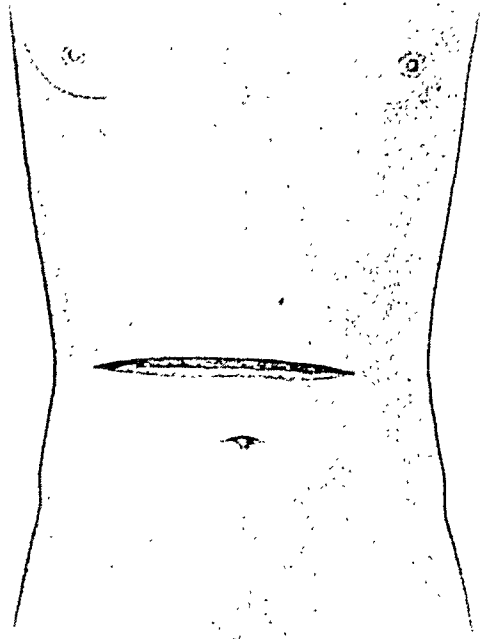


FIG. 3.—Showing transverse incision down to anterior rectus sheaths. For operations on the biliary tract, it is slightly longer to the right of the midline. For splenectomy, extension should be to the left.

the posterior structures divided in a transverse direction. He commended this procedure for exposure of the operative field and preservation of the nerve and blood supply. Further, he stated that it eliminates danger of wound infection, prevents postoperative adhesions, and is easily closed. He offered the criticism himself that the combined vertical and transverse openings involve too much cutting in opening and the expenditure of too much time in closing. It may be said, also, that by this method a large, loose space is created between the superficial fat and the anterior sheaths for the accumulation of serum.

Singleton opens the skin and fat transversely, then dissects them widely from the anterior sheaths up and down, especially on the right. The anterior sheath over the right rectus is incised vertically and the muscle retracted. A short transverse opening is then made over the left rectus to afford ample

retraction of the muscle. The entire posterior wall is separated transversely. This permits excellent exposure.

Singleton admits that his extensive detachment of the superficial tissues

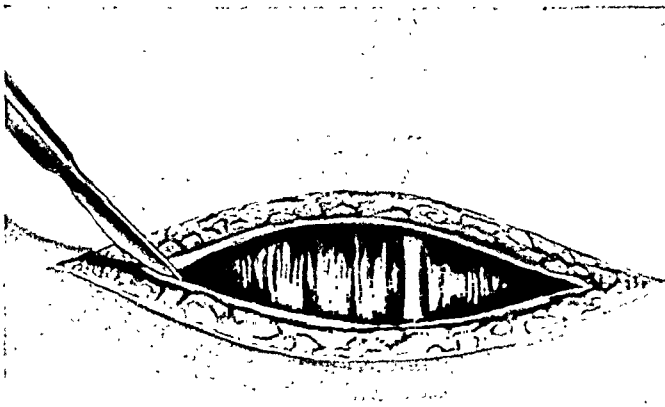


FIG. 4.—Showing the incision extended through the anterior sheaths of the recti and dividing the linea alba.

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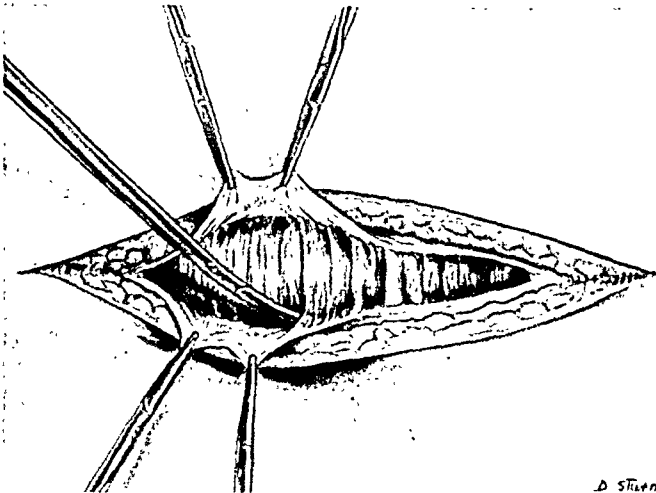


FIG. 5.—Showing separation of anterior sheaths above and below from their attachments to the muscles.

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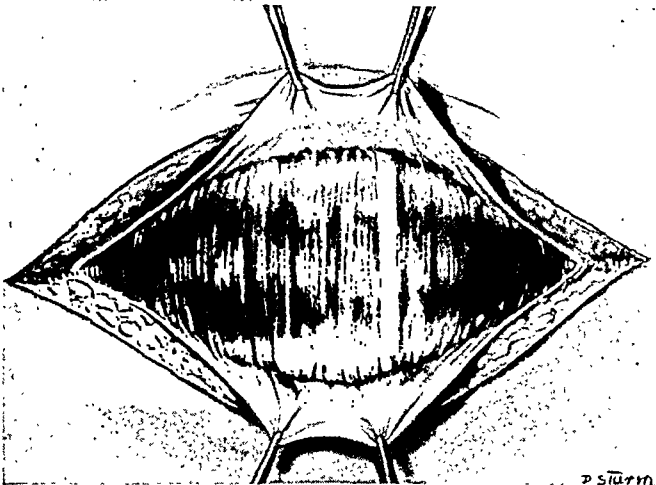


FIG. 6.—Showing separation of the sheaths and muscles completed, ready for lateral retraction of the muscles.

D. Sturm

creates a "dead space," as in Sloan's procedure, and predisposes to the collection of serum. This may be absorbed or may, on the other hand, become infected and demand drainage.

The Bartletts propose a "staggered" transverse incision. They open the skin and fat in one layer, the anterior sheaths alone a little higher, the recti at a level below the first incision, and the posterior sheaths on a plane with

FIG. 7.—Showing recti retracted wider to right. The aponeurotic fibers of the posterior sheaths are being separated and the linea alba divided.

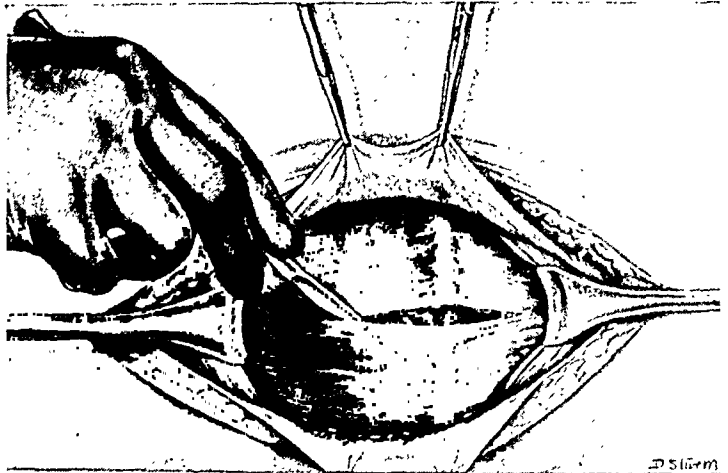


FIG. 8.—Showing the peritoneum open and the transverse colon being divided between clamps.

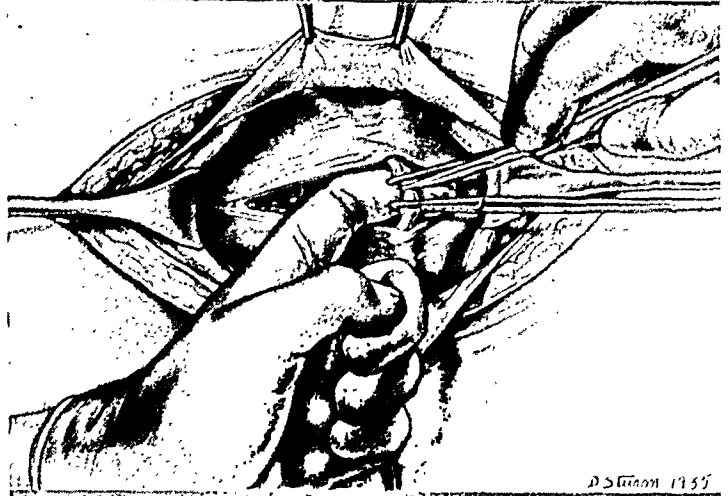
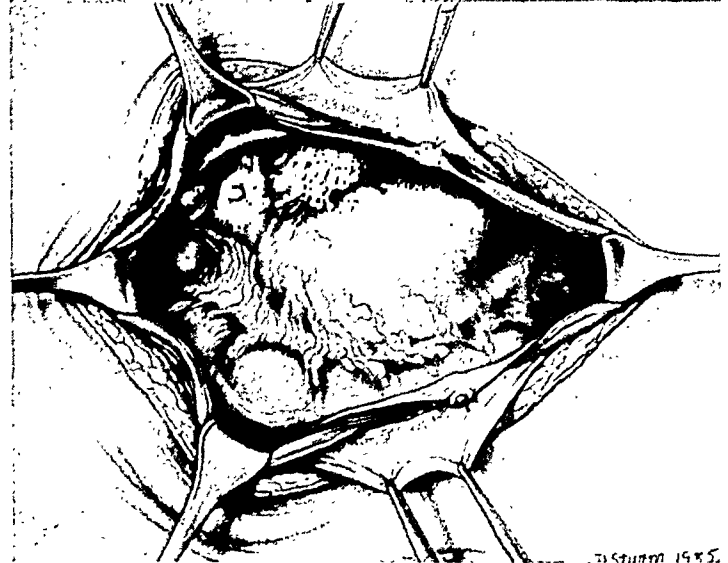


FIG. 9.—Showing stumps of falciform ligament ligated. Wound widely separated by retractors. Liver margin, gallbladder, stomach, duodenum, and transverse colon easily exposed.



the opening in the anterior sheaths. According to their theory, closure of the wall in various planes gives a "muscle lined" wound and prevents a tendency to extrusion of the viscera and postoperative hernia. They say, however, that until the surgeon has had some practice with this type, he will

spend more time working on the abdominal wall than within it, but declare that rapidity of execution comes with experience, and the additional time is well spent.

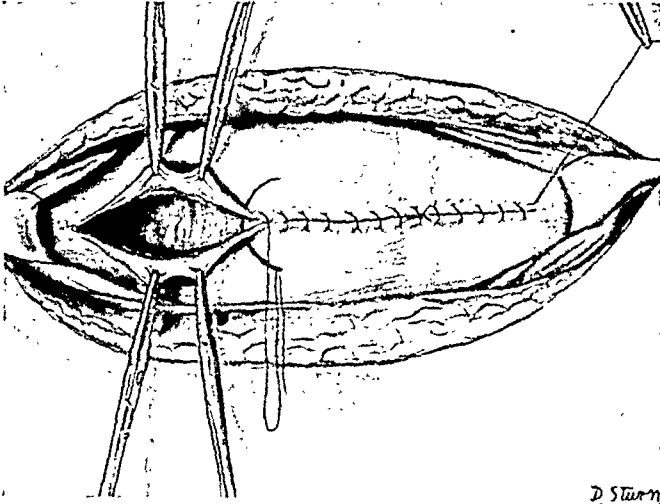


FIG. 10.—Showing closure of peritoneum and posterior sheaths from left to right, without tension. Muscles still retracted.

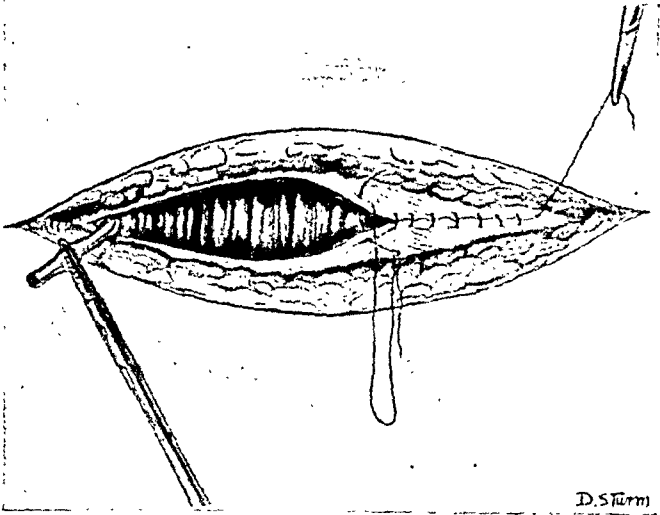


FIG. 11.—Showing recti replaced and anterior sheaths being sutured. Drain tube lateral to right rectus.

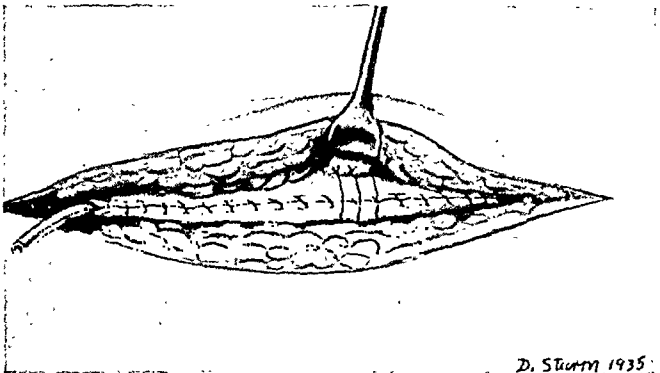


FIG. 12.—Showing fascial suture complete. Three interrupted chromic catgut sutures through linea alba.

C. U. Collins, in 1907, seems to have been the originator of a technic which was described again, in principle, by Souther in 1911, McArthur in 1912, and Schwyzer in 1934. These surgeons have advocated a vertical opening through the superficial structures and anterior sheath of the rectus

muscle on the right side. The muscles are then retracted and the posterior sheath and peritoneum opened transversely. If additional room is needed, the linea alba is divided.

It seems that the principal point upon which there is a divergence of thought is the advisability of severing the recti. Farr,⁶ Quain, Moore,¹⁷ and Southam²⁸ cut them across without so much as a preliminary suture, believing that, since they retract only in segments, an adequate repair may be made by closure of the anterior aponeuroses. Moschcowitz and Jones and McClure⁷ suture the muscles to the anterior sheaths on opening, not merely to prevent retraction and exact end to end closure, but chiefly to insure hemostasis. Sloan says the recti have an important function and should not be severed. A number of us agree with him. Others contend that retraction of the muscles sufficiently wide to afford an ample operative field may cause hemorrhage, damage to the nerve supply, and rupture of the muscle fibers to such an extent as to endanger the integrity of the wall. It is clear, therefore, that the different experiences of each surgeon are responsible for the number and variety of transverse incisions devised during the past few decades.

It should not be forgotten that the majority of these incisions may be extended in one direction or another in an approach to the kidneys, spleen, and even the appendix. In my own work, however, when a cholecystectomy and appendectomy are to be done at the same time, unless the appendix is lying very high, I prefer removing it through a separate incision, usually the McBurney.

My interest in the transverse incision in the upper abdomen was stimu-

TABLE I

OPERATIVE PROCEDURES PERFORMED THROUGH A TRANSVERSE INCISION	
Stomach.—Pyloroplasty.....	6
Gastro-enterostomy.....	7
Gastrectomy (partial).....	1
Biliary Tract.—Cholecystectomy.....	35
Cholecystectomy and appendectomy*.....	7
Choledochotomy.....	5
Cholecystogastrostomy.....	3
Miscellaneous.—Splenectomy.....	1
Abdominal exploration.....	7
Drainage liver abscess.....	1
Liberation intestinal adhesions.....	1
Duodenal ulcer, perforated.....	2
Nephrectomy, for sarcoma kidney (left rectus divided).....	1
	—
	Total 77

* The appendix was removed through a separate McBurney incision in 11 cases.

One transverse incision required secondary closure on account of extensive infection.

lated largely by the difficulties encountered in using a vertical one. I was disappointed in the high percentage of ventral herniae and weakened abdominal walls which followed. Disabling and distressing adhesions, to the parietal peritoneum throughout the entire length of the vertical incision, were observed far too often to be of passing interest. Postoperative pain was not a negligible matter. With these considerations in mind, my first operation through a transverse incision was done in March, 1934.

Since that time, 77 supra-umbilical transverse incisions have been made (Table I). In the beginning, Sloan's technic was employed exclusively. Soon it was discovered that this method required too much surgery, particularly in closing the wound, when there were two parallel openings in the fascia. The Singleton type was then tried, with better success. In Singleton's procedure, however, the surgery was almost as extensive and, in addition, the large space between the sheaths and fat became, in a number of cases, a depository for serum. The technic was a little difficult to master, and our first dozen or more cases were not done well. On this account, we were rather discouraged over the prospect of adopting the incision for general use. About one year ago we tried a modification of the former incisions, as described in the accompanying illustrations. So far as I am able to learn from a careful review of the literature, this technic has not been presented heretofore.

Operative Technic.—For cosmetic effect, the skin incision is made equidistant on each side of the midline. To be adequate, it should extend practically from one costal margin to the other. The opening in the subcutaneous structures, however, should be farther to the right than to the left of the midline for operations on the biliary tract. The exact site of the incision will be determined largely by the width of the costal angle: the wider the angle, the higher above the umbilicus should the incision be placed. In the average patient, the juncture of the middle and lower thirds of the distance between the xiphoid and umbilicus and between two of the linea transversae is the most effective location.

The opening is carried down to the anterior sheaths of the rectus muscles. No dissection is made longitudinally, as simple retraction of the wound is all that is necessary for exposure of the sheaths.

The anterior sheaths are then divided in line with their fibers. Here, the technic is most tedious and difficult. Since the recti are densely adherent anteriorly to the sheaths, especially at the linea transversae, one must elevate the sheaths carefully and, with scissors, dissect the muscles free for a distance of two or three inches up and down. Occasionally, hemorrhage is a little troublesome. Extreme caution must be exercised in liberating the sheaths from the linea transversae, otherwise the muscles may be weakened and their fibers more easily torn by retraction. On the posterior side of the muscles the sheaths can be freed without difficulty, as they adhere only slightly.

Both recti are now retracted laterally and the opening is continued transversely through the posterior sheaths and peritoneum. The falciform liga-

ment is divided between clamps, the ends ligated and dropped back. With adequate retractors, the wound is opened wide for exploration or operative procedure.

Drainage tubes may be brought out through the right angle of the wound lateral to the rectus muscle. This affords a more direct and even more dependent drainage than is obtainable through the vertical incision.

The wound may now be closed in layers, as any other type of abdominal incision. Suturing is more readily accomplished if begun on the left. Since the peritoneum and posterior sheaths are so adherent, they may be closed

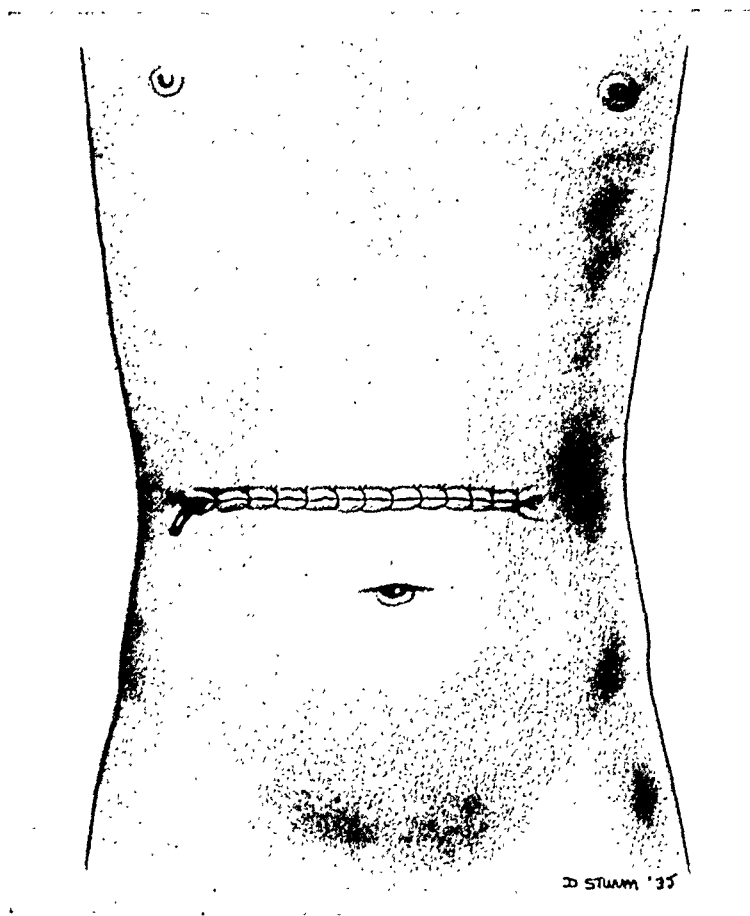


FIG. 13.—Showing operation complete. Skin closed with interrupted suture. Drain through right angle.

together. The divided ends of the falciform ligament may be approximated by including them in the suture. Even though the patient is straining, there is no tension on the wound and its edges may be drawn together with ease. The rectus muscles are then brought to their normal position and the anterior sheaths closed in a similar manner. When the operation is complete, three interrupted sutures of chromic catgut are placed in the linea alba as an additional measure of safety. Retention sutures are unnecessary, but may be used if desired.

In the average case, exposure is ample, and the gallbladder and ducts are easily accessible through this incision. If the operation is to be a high stomach resection, an extension may be made to the left to equal that to the right.

If the appendix is to be removed and the cecum is fairly mobile, this same opening will usually suffice. In many cases, however, an additional McBurney incision may be required for appendectomy.

Schwytzer has called attention to the fact that the gallbladder may be removed through the transverse incision without severing the linea alba or extending the opening to the left side. We have been able to do this in two instances.

In the last 50 cases the foregoing method has been satisfactory in every particular. By eliminating the wide dissection of the superficial structures, we have no dead space for the accumulation of serum or blood. Patients have suffered appreciably less postoperative pain and less distention and distress, and healing has been more rapid. In two of our early cases the linea alba separated, resulting in a moderate bulge and some weakening of the wall. In both these there was extensive suppuration, which was secondary to a badly infected gallbladder in one, and a long drainage of the common duct in the other. As both operations were done before we were familiar with the technic, we failed to bring out the drainage tube lateral to the right rectus muscle. From our more recent transverse incisions, in which we have been reinforcing the linea alba with three interrupted sutures, we have not yet had any adverse results.

We have not adopted this incision for all supra-umbilical operations. With further experience, however, and the exercise of patience and careful attention to detail, we believe it can be employed safely and successfully in practically every one. Fortunately, its application is easiest in those patients who need it most. In doing a considerable amount of upper abdominal surgery, one deals with many large, obese men and women beyond middle age, whose abdominal walls are composed chiefly of fat and thinned out, flabby muscles and fascia. The peritoneum and posterior sheaths are especially thin and friable, making closure of that layer difficult and uncertain. The omentum is thick and, in many cases, the peritoneal cavity seems too full of viscera. As these patients generally take the anesthetic poorly, respiratory effort is increased and wound closure is more difficult. From the standpoint of facility in opening and closing, the transverse incision is particularly advantageous in this group of patients.

Disruption of a vertical wound is to be expected in a small number of the cases just described. It occurs all too frequently, and is a serious and formidable complication. Singleton studied 900 cases reported from several hospitals and found a total mortality of 38 per cent from disruption alone. By the use of the transverse principle, one can eliminate almost entirely this dangerous possibility and thus reduce appreciably the mortality from surgery in the upper abdomen.

Although the various types of transverse incisions differ in one or two respects, all have a number of virtues in common. Of the majority of them, we may say that:

(1) They conform to anatomic and physiologic requirements by follow-

ing the course of the wall structures and preserving the nerve and blood supply.

(2) They promote rapid healing of the wound because of the natural tendency of the edges to come together and the lack of strain upon the sutures.

(3) They lessen the danger of trauma to the tissues, since the fibers which run parallel to the line of incision are sutured across.

(4) They preserve the peritoneum intact in closure.

(5) They permit perfect apposition of the wound edges and, except when extensive superficial dissection has been made, prevent dead space for the accumulation of serum.

(6) They prevent shock of the patient on account of the lack of retraction of the wound margins.

(7) They reduce postoperative pain to a minimum.

(8) They shorten the time of hospitalization and hasten the patient's recovery.

(9) They give an excellent cosmetic result.

(10) They afford ample room and freedom of movement, with an excellent view of the operative field.

(11) They obviate the necessity for extensive packing of the abdominal cavity and thus tend to reduce the amount of postoperative adhesions.

(12) They allow more efficient drainage at a dependent site, and without subsequent damage to the integrity of the abdominal wall.

(13) They reduce materially the danger of postoperative hernia.

(14) They lower mortality from upper abdominal surgery by eliminating almost wholly the possibility of wound disruption.

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EXPERIMENTAL STUDIES OF URETERO-INTESTINAL ANASTOMOSIS

A PRELIMINARY REPORT

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THE employment of uretero-intestinal anastomosis in cancer of the bladder, exstrophy of the bladder, irreparable vesicovaginal fistulae and a few cases of intractable chronic interstitial cystitis has become an accepted surgical procedure. It is obvious from the nature of the two structures to be united, that in order to avoid serious complications, technical skill is required in the performance of the operation. Several different technics of ureteral transplantation have been described. The purpose of the experiments set forth in this paper is to observe in animals the results obtained in the application of the different technics.

Inasmuch as a detailed report of each experiment cannot be undertaken within the limits of this paper, the experiments are discussed in groups and subgroups as follows:

Group I: Ureteral transplantation by the aid of catheters, Coffey's¹ second technic (four experiments).

Group II: Ureteral transplantation by means of a transfixion suture, Coffey's third technic² (ten experiments).

Subgroup II A: Simultaneous transplantation of both ureters by Coffey's third technic (one experiment).

Group III: Ureteral transplantation in two stages, a method described by Ferguson³ (17 experiments).

Group IV: Ureteral transplantation by a combination of Ferguson's first stage and Coffey's transfixion suture, a method developed and perfected by Higgins⁴ (four experiments).

Group V: A two stage method of ureteral transplantation in which Ferguson's first stage operation is followed by Coffey's⁵ (six experiments).

Group VI: A two stage operation. In the first stage a portion of the ureter overlooped with a silver wire is placed within the lumen of the sigmoid. The anastomosis is completed through the rectum at a later date by dividing the ureters with cutting current (two experiments).

Group VII: A two stage method. With the aid of a linen thread looped over the ureter at the first operation, at the second stage, which is performed through the rectum, the intestinal mucosa is incised longitudinally and the ureter transversely with the cutting current (two experiments).

Subgroup VII A: The technic employed in Group VII is modified by the substitution of silver wire for linen thread (eight experiments).

Subgroup VII B: An addition is here made to the technic of Group VII A by strangulating a triangular area of the intestinal mucosa covering the ureters and the wire loop, by means of three linen sutures (one experiment).

Group VIII: A two stage operation. As the ureters are embedded in the bowel wall, they are wrapped together in a cuff of tin foil, cellophane, or oiled silk one-half inch wide around which is looped a silver wire. At a later date the operation is completed through the rectum by means of the cutting current (six experiments).

Group IX: A two stage method. As the ureters are implanted in the rectal wall, they are inclosed together in a cuff of sheet tin one-half inch wide. The anastomosis is later completed through the rectum by incising the mucosa of the bowel longitudinally and the ureters transversely at the caudal end of the cuff which allows its removal (three experiments).

EXPERIMENTS

Group I: Bilateral ureteral transplantation was performed on four dogs (3, 4, 5 and 6) employing the catheter method described by Coffey as Technic No. 2. Death from peritonitis resulted in each dog within a week. Moreover, it was impossible to keep the catheters in place and functioning. The method was, therefore, abandoned.

Group II: In ten dogs (1, 2, 7, 8, 9, 10, 11, 12, 13 and 14) the ureters were transplanted individually by the transfixion suture method of Coffey described as his third technic. Dog No. 7 lived six months after the second transplantation. Postmortem revealed a normal urinary tract above the anastomosis. Dog No. 8 died suddenly 38 days after one ureter, the left, had been transplanted. Autopsy revealed a normal left kidney, but there was a moderate dilatation of the left ureter. Dog No. 11 survived the second transplantation 105 days. At autopsy it was found that the left kidney, 150 days after transplantation, was a large tense hydronephrotic sac, whereas the right kidney, 105 days after transplantation, was normal. In these three cases, linen was used for the transfixion suture.

In seven other animals catgut was used in two, silver wire in two, and linen in three for the transfixion suture. Three of these dogs after the first transplantation died of peritonitis, living an average of five days. Four died after the second transplantation, surviving an average of four days. In one dog the wire transfixion suture was tightened by twisting it within the rectum. The use of wire as a transfixion suture was thereafter abandoned because in tightening it the tissues were usually torn. Except 7, 8 and 11, all dogs of this group that survived the operation long enough developed obstruction at the site of anastomosis. In one animal the anastomotic fistula had completely closed after 150 days.

Subgroup II A: In one animal (15) both ureters were transplanted at the same operation according to Coffey's third technic. The dog lived two days and died of peritonitis. At autopsy it was found that both kidneys were swollen and congested. There was obstruction at the anastomosis.

Group III: Seventeen dogs (19, 20, 21, 22, 23, 24, 25, 26, 28, 29, 31, 32, 33, 34, 35, 37 and 42) were operated upon by a method derived from Ferguson.³ The first operation consisted of embedding the ureters in the bowel wall between the muscularis and mucosa for one and one-half inches without interrupting their course to the bladder. In four animals (19, 20, 21 and 22) both ureters were embedded together in a single longitudinal incision, one and one-half inches long, on the anterior aspect of the bowel wall. In ten instances, to prevent angulation of the ureters, a T-shaped incision was employed (23, 24, 25, 26, 29, 31, 32, 33, 34 and 35) so that each ureter entered the bowel wall at its mesenteric border and, running a diagonal course, emerged together

URETERO-INTESTINAL ANASTOMOSIS

with its fellow in the midline opposite the mesentery. In three instances (28, 37 and 42), two separate incisions at different levels on the bowel wall were employed to implant the respective ureters. Table I illustrates the immediate mortality and the effect of this operation on the nonprotein nitrogen of the blood at given intervals in 21 dogs.

Only two died, one (42) of rabies within ten days, the other of peritonitis six days after the operation. In the latter dog the sigmoid was so distended with hard fecal masses at the time of operation that it was impossible to properly close the muscle layer and serosa over the ureter. In spite of the low mortality of this operation, we observed that immediately postoperative there was a rise in the nonprotein nitrogen of the blood. This

TABLE I
IMMEDIATE MORTALITY AND POSTOPERATIVE NONPROTEIN NITROGEN
RETENTION IN 21 DOGS

Dog No.	Days After First Stage	Mg. of N.P.N.
1.....	60	40
2.....	57	36.1
3.....	59	30
4.....	60	22.2
5.....	59	25.5
6.....	60	32.4
7 (Died of peritonitis six days after first stage)		
8.....	61	38.7
9.....	105	33.3
10.....	96	30.7
11.....	100	36.3
12.....	70	33.3
13.....	49	33.3
14.....	52	36.3
15.....	50	37.5
16.....	50	35.2
17.....	26	37.5
18.....	41	33.3
19.....	42	26
20.....	45	25.5
21 (Died of rabies)		

is due to swelling and hemorrhage into the intestinal wall around the embedded ureters, and to denervation of the ureters which we believe must necessarily accompany their mobilization. Ferguson² recommended catheter drainage to prevent ureteral obstruction. The obstruction as evidenced by elevated nonprotein nitrogen spontaneously disappeared within the first 10 to 15 days postoperative. In Chart I the line A represents the level of nonprotein nitrogen of the blood following simple mobilization of both ureters. In the same figure, line C represents the curve of the nonprotein nitrogen of the blood when the operation is completed by embedding the ureters within the wall of the sigmoid.

From these figures it is found that in the average dog, two months after this operation, the nonprotein nitrogen level was 33.3 mg. (The average level of nonprotein nitrogen in a series of ten dogs before operation had been done was exactly 33.3 mg.)

Fifteen of these dogs (19, 20, 21, 22, 23, 24, 25, 26, 28, 29, 31, 33, 34, 35 and 37) were subjected to a second stage operation which was similar to the technic described by Ferguson. The abdomen was reopened and the field of anastomosis exposed. The ureters were divided one inch below their exit from the bowel wall. A small wire, insulated except near the tip, was introduced into the ureters and passed into the lower third of their intramural portion. The insulated handle of the wire was then elevated

so that its long axis became perpendicular to the intestinal mucosa. In this position the high frequency current was applied and the wire passed through the wall of the ureter and underlying intestinal mucous membrane into the lumen of the bowel. The current was then changed to a coagulating current and allowed to remain on while the instrument was withdrawn through the stump of the ureter. The ureteral ends were then ligated with silk. After using the wire in six (19, 20, 21, 22, 25 and 34) animals it was discarded for an insulated wire loop which was employed in nine (23, 24, 26, 28, 29, 31, 33, 35 and 37) instances. The ureteral ends were ligated with catgut and buried within the bowel wall.

Results.—One dog (26) survived the second stage operation for seven months and 19 days. Autopsy revealed a large infected left hydronephrosis and a very large left ureter, almost completely obstructed at the site of anastomosis. The right kidney and ureter were normal. One dog (29) died 44 days after operation. At autopsy the left ureter was completely occluded at the site of anastomosis, where a scar marked the site of the closed fistula. Bilateral hydronephrosis was present. In both dogs (26 and 29) the communication between ureter and intestine had been cut by a wire loop.

The average life of the 13 remaining animals was ten days. At autopsy a large perirectal abscess was found in five and generalized peritonitis in three. In 11 dogs obstruction was demonstrated at the anastomosis.

Group IV: In four experiments (16, 17, 18 and 27) Ferguson's first stage operation was combined with Coffey's transfixion suture method. The ureters were embedded in the intestinal wall and at the same time they, with the intestinal mucosa, were transfixed by a linen suture at a point near the ureteral exit from the bowel wall. Care was taken not to interrupt ureteral continuity.

Results.—One dog (16) lived 11 days. At autopsy the cause of death was undetermined. Both kidneys were grossly normal. The left ureter drained freely into the bowel, whereas the right ureter drained with equal freedom into the bladder. The remaining three dogs died of acute peritonitis within the first 72 hours. In these three the transfixion sutures were still present,

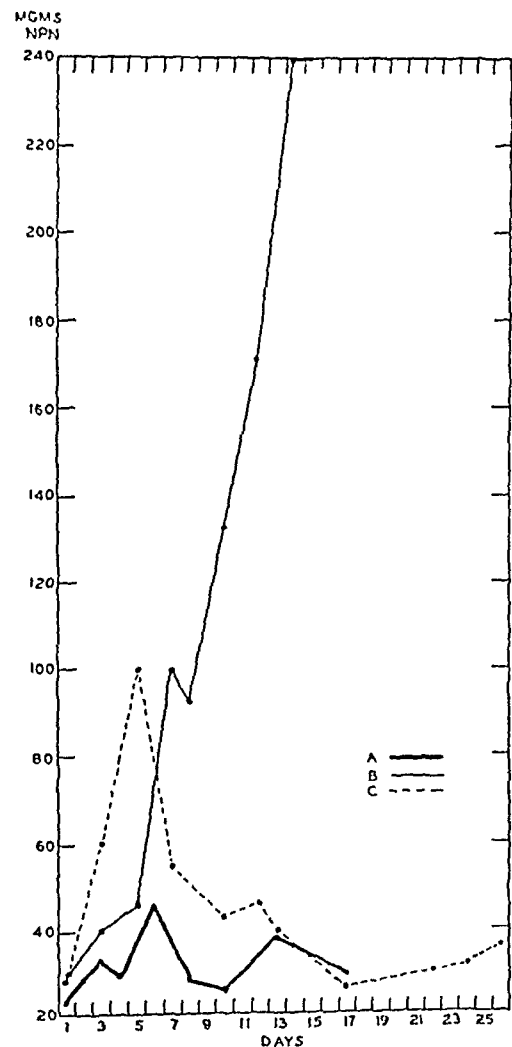


CHART I.

having cut through the intestinal mucosa but not the ureteral wall. Urine was found within the peritoneal cavity of two. In all hydronephrosis and hydro-ureter were already present. In one dog it appeared that the transfixion sutures, which had been put through the ureter transversely, partially occluded the lumen of the ureter. In the last experiment, therefore, the ureters were transfixed in their longitudinal direction rather than crosswise.

Group V: In six dogs (36, 38, 39, 40, 43 and 44) Ferguson's first stage operation was followed after an elapsed average time of four weeks by the following technic.

The ureters were divided one inch below their exit from the bowel wall. Great care was used to dissect the ureteral stumps well back into the wall of the intestine, so that the stab wound into the bowel through which the ureters passed had no muscular tissue intervening between it and the ureter. A stab wound was then made through the bowel wall at a point adjacent to the ureter as it emerged. The ends of the ureters were then passed through these wounds into the lumen of the bowel and the muscle and serosa closed over and around them. (It is surprising to observe how much the ureter retracts after its division. When the stumps have been cut an inch long, after retraction barely sufficient lengths remain for proper invagination.)

Results.—One of these dogs (39) lived nearly two years, and died of causes other than renal failure. One dog (36) died of pneumonia on the ninth day; the urinary tract was normal. Two dogs died of renal infection (43) on the twelfth and (44) on twenty-third postoperative days, and in each case there was unilateral partial ureteral obstruction. In dog No. 44 obstruction was due to a plug of mucus or exudate rather than stricture. This was determined by injecting water into the ureter above the anastomosis and observing its flow into the bowel. No water came through the anastomosis until considerable pressure had been built up within the ureter. Suddenly a small plug of exudate was expelled through the anastomosis, followed by a continuous free flow of the water through the anastomosis. In dog No. 43 obstruction resulted from acute angulation of the ureter at its point of entrance into the lumen of the bowel. Finally, one of these dogs (43) had a mild inflammatory lesion in the kidney which was not due to obstruction. The remaining two dogs (38 and 40) died of peritonitis within 72 hours following the second operation.

Group VI: An additional technic was employed in two dogs (41 and 45). In these, the ureters were embedded in the wall of the bowel in the usual manner except that in the lower third of the intestinal incision the mucous membrane was incised for a distance of one-half inch. Strands of silver wire, size 27, were looped over the ureters and passed through these incisions into the lumen of the bowel. The mucosa was then closed over the ureters and their encircling wire, so that for a short distance they were actually within the lumen of the intestine. Had these wounds healed, we planned to complete the operation through the rectum by dividing the ureters with the high frequency current. Both dogs, however, died of peritonitis within the first 72 hours.

From the foregoing 44 experiments we have concluded:

(1) Animals rarely tolerate a method of uretero-intestinal anastomosis which requires that both the bowel and ureter be opened at the same operation within the peritoneal cavity.

(2) The first stage of Ferguson's operation immediately produces partial blocking of the ureter, due to swelling, induration, and hemorrhage in the bowel wall which surrounds the ureters and, in a lesser measure, to ureteral denervation. The obstruction is manifested by diminution in the output of urine and an increase in nonprotein nitrogen of the blood which, in the average case, reaches a maximum of 100 mg. on the fifth postoperative day. The obstruction has always been spontaneously relieved, usually by the fifteenth postoperative day, and has occasioned no demonstrable permanent renal changes.

(3) Destructive renal changes often become apparent at remote intervals following bilateral ureteral transplantation. In the great majority of cases, if Coffey's principle of transplantation has been employed, lesions in the kidneys are due to stricture or obstruction at the point of anastomosis rather than to an ascending infection through the anastomosis.

This suggests the desirability of maintaining the patency of the ureter by mechanical dilatation during the healing process and, possibly, at intervals thereafter.

(4) The creation of a fistula between the ureter and the bowel by a transfixion suture, Coffey's third technic, has been unsuccessful in the majority of our experiments. It has been of value in decreasing the immediate mortality due to infection, but the transfixion suture has been inefficient in cutting through promptly and completely leading to an inadequate fistula. Two reasons may be advanced for its inefficiency, assuming of course that it were properly placed: first, the knot may slip so that sufficient pressure to cause a slough is not maintained; second, it is entirely possible that when two structures of different texture are included within the same ligature, the most easily strangulated cuts through first, loosening the tension on the other so that it is able to remain intact.

(5) The second stage of Ferguson's operation also proved unsuccessful in our hands. It has the same objections as Coffey's transfixion suture. In the great majority of our cases we were unable to complete an amastomosis which remained competent. Furthermore, there occurred a high incidence of associated localized infections.

(6) Ureteral obstruction due to stricture at the site of uretero-intestinal anastomosis more frequently follows side-to-side anastomosis. Permanent patency of the anastomosis is best attained by bringing the end of the ureter into the lumen of the bowel, an end-to-side anastomosis. Because of the retractility of the ureter when severed, an excess of the ureter should be brought within the lumen of the intestine, so that its end will not retract into the bowel wall, producing subsequent obstruction. Retraction may account for some of the undesirable late results following Coffey's first technic.

(7) During the period of ureteral obstruction when little or no urine is passing through the anastomosis mucus, fibrin or blood may accumulate within the lumen of the ureter and produce obstruction.

(8) Very frequently infections within the abdominal wound may delay secondary laparotomy.

(9) At the second stage operation the site of uretero-intestinal anastomosis is frequently firmly adherent to the surrounding structures. The field of operation is, therefore, difficult to expose. Many adhesions must be separated and hemostasis may be difficult.

It is apparent that there are many advantages in allowing the ureters to become firmly healed within the wall of the bowel before a communication is established between them. These advantages we believe are largely annulled if the anastomosis is completed by a secondary abdominal operation.

Following the first stage transplantation of ureters the intramural parts of the ureters are separated from the lumen of the bowel by only a thin layer of mucous membrane. Because of this relationship the rectum offers a satisfactory avenue through which to approach the second stage operation. On the other hand it adds other problems, the chief being the restricted area in which the

operation must be conducted. We have, therefore, sought to modify Ferguson's first stage operation in some manner, which, without increasing its risk would enable us to complete the anastomosis by the intrarectal approach.

To this end the following experiments have been carried out.

EXPERIMENTS

Group VII: At the first stage operation a linen thread with needles on either end was looped over the ureter in the lower third of its intramural course by passing a needle on each side of the ureter through the mucosa into the lumen of the intestine. These needles were caught with forceps through a proctoscope and pulled through the anus. This portion of the ureter was then buried in a fold of mucous membrane by three mattress sutures of linen. The muscle and serosa were next closed over all. The ends of the thread were fastened together well within the rectum and the excess thread cut off to prevent the dog from interfering with it. Two dogs (46 and 47) were operated upon in this manner, only the right ureters being implanted. The anastomosis was to have been completed later by dividing the ureter from within the rectum with the high frequency current using the linen thread as a guide. In the first dog (46) after 19 days the thread had disappeared. This dog died 27 days later, and autopsy revealed that death was due to peritonitis. In the second dog (47) ten days after the first stage operation we were able to locate the thread through the proctoscope but during our manipulations the thread was accidentally broken and pulled out. The linen had apparently been disintegrated by the intestinal fluids and was not employed thereafter.

Subgroup VII A: In eight dogs (48, 49, 50, 52, 53, 54, 55 and 57) both ureters were implanted simultaneously without interrupting their course to the bladder, and in addition silver wire, size 27, was looped over them instead of linen thread. In three dogs (48, 49 and 50) the ureters were embedded in separate incisions, necessitating the use of two wires.

In the first dog (48) the wires had disappeared at the end of 14 days. When the second stage was attempted the animal was apparently in good health. The second dog (49) was found dead in his cage on the morning of the fifth postoperative day. The abdominal wound had disrupted. The third dog (50) died under the anesthetic. In the remaining five animals (52, 53, 54, 55 and 57) the operation was simplified by embedding both ureters in a single incision and using one wire loop to include both ureters. In the first dog (52) the wire was cut out with difficulty at the end of ten days. Fourteen days later he died in uremia with a nonprotein nitrogen of 120 mg. Bilateral hydronephrosis was found at autopsy. In the next case (53) the second stage was again performed with considerable difficulty, three weeks after the first operation. Four days postoperatively the dog died of renal failure. At autopsy there was an advanced hydronephrosis of both kidneys and both ureters were enormously dilated. The cause of obstruction was difficult of explanation since both anastomoses emitted water freely and without undue pressure when injected above their union with the bowel.

At this time it was discovered that the two limbs of the wire loop, each about four inches long, were not insulated. The current was therefore leaking. This was corrected.

Dog No. 54 gradually lost weight and strength following the first stage operation and died on the fourteenth postoperative day before the second stage operation was attempted. Postmortem examination revealed a large fecal impaction accumulated on the coiled ends of the wire loop. The ureters were definitely obstructed by the wire loop. After the wire was removed the obstruction was relieved. Dog No. 55 died about one hour after the first stage operation. He did not react from the anesthetic. The fifth dog did well immediately after the first stage. Seven weeks later, however, when the second stage was attempted, it was discovered that the wires were not in place. Roentgenograms substantiated their absence. At this time it was not clear why we so often found hydronephrosis and hydro-ureter after the second stage when no obstruction could

be demonstrated in the anastomosis at autopsy. We were inclined to believe, however, that in some way the second stage was at fault. On this hypothesis we attempted to improve the second stage by bringing an excess of the ureteral stump into the lumen of the bowel as is done in Coffey's first technic. The above method therefore was further modified in an effort to accomplish this purpose.

Subgroup VII B: Three sutures of linen were passed through the mucous membrane and out again at a distance of about one-third inch. These three sutures formed a triangle with its apex above and its base below. Within the area of this triangle the two limbs of the wire loop over the ureters were passed into the rectum. When the three sutures were tied the blood supply was completely cut off to the mucosa within their confines. After sloughing occurred, the ureters, with the wire looped over them, for about one-third inch, were exposed within the lumen of the bowel. This experiment was performed on one dog, No. 56.

Dog 56 died on the sixth postoperative day. Autopsy revealed that the strangulated mucous membrane had sloughed. The portions of the ureters which had become exposed by this slough were necrotic and the muscularis and serosa had failed to heal over this area. The result was a localized abscess from perforation of the bowel. It is of the utmost importance, therefore, to preserve the mucous membrane of the bowel as a protection against infection while the ureters are healing within the intestinal wound.

Group VIII: In order to meet this situation the first stage was again modified. The ureters were embedded in bowel wall, using a T-shaped incision, and in addition they were surrounded by a cuff of tin foil one-half inch wide. The wire loop was so placed that it embraced the ureters over this cuff. The purpose of this cuff was to prevent the ureters from becoming adherent to the bowel wall in the lower third of their intramural portion. At the second operation we proposed to incise the mucous membrane in a longitudinal direction between the limbs of the wire loop for the distance of one-half inch. Then by making traction on the loop we could bring the tin foil into view through this incision. The ureters were to be severed at the lower end of the cuff so that the loop and the cuff, together with the ends of the ureter, would be pulled into the lumen of the intestine. In this manner it was hoped that we would secure the same end result accomplished by Coffey's first operation. Six dogs (59, 60, 61, 62, 63 and 64) were operated upon in this manner. In three (59, 60 and 64) tin foil was used to enclose the ureter. No. 59 lost weight after the first stage. A week later when the nonprotein nitrogen of the blood had risen to 63.1 mg., the second stage was performed. The animal survived the second stage 18 weeks and died because of ureteral obstruction. Dog No. 60 died of pneumonia four days after the first operation. In dog No. 64 the nonprotein nitrogen of the blood was 100 mg. on the fourteenth postoperative day. The second stage was then attempted but it was found that stricture of the bowel had occurred at the point of anastomosis. The second stage could not, therefore, be carried out. This was the first time that we had encountered a definite stricture of the intestine following the use of a T-shaped incision in the muscularis. In four instances there had been some narrowing of the bowel wall at the anastomosis, which was detectable in passing a large sized proctoscope. However, the proctoscope had always passed through anastomotic section of the bowel with little difficulty. On the nineteenth postoperative day the dog died. Autopsy revealed a pronounced stricture of the bowel. Above this stricture the intestine was dilated to four times its size and filled with fecal material, whereas below this stricture the rectum was empty and collapsed. There was, in addition, bilateral ureteral obstruction which had resulted in hydro-ureter and hydronephrosis.

In dog No. 61 cellophane was used as a cuff instead of tin foil. The first stage was well tolerated and two weeks later the second stage was attempted but, unfortunately, during our manipulation a limb of the wire loop caught in the window of the proctoscope and was pulled out. About four weeks later the dog was in good health with the non-protein nitrogen of the blood at 50 mg.

In the last two experiments (62 and 63) oiled silk was substituted for cellophane.

The latter material was found to be much easier to handle. Dog No. 62 died of pneumonia 12 days after the first stage. Autopsy revealed normal kidneys and only slight dilatation of the ureters. There was, however, a moderate degree of constriction of the bowel at the point of the anastomosis. Dog No. 63 lost weight after the first stage. On the fourteenth postoperative day the second stage was successfully performed through the proctoscope by incising the intestinal mucosa longitudinally between the limbs of the wire loop with the cutting current. The incision was begun about one-third inch beyond the loop and brought forward. While traction was being made on the loop the electrode came in too close proximity to one of its limbs, causing the loop quite unexpectedly to cut through both ureters. However, we were able to visualize the field of operation and extract the oiled silk with forceps. In removing the oiled silk the ends of both ureters were delivered into the lumen of the bowel. The result of this second stage, therefore, was in a mechanical sense the ideal for which we had worked. We were surprised to learn that this dog's blood drawn at the time of the operation contained 240 mg. of nonprotein nitrogen per 100 cc. of blood. The dog survived the second stage five days and postmortem revealed bilateral pyelonephritis which had already destroyed most of the kidney substance. There was no dilatation of the pelvis of either kidney or of either ureter. No obstruction in the anastomosis could be demonstrated.

Postmortem examination of the intestinal mucous membrane at the point where the wire loop had cut out revealed a small elliptical ulcer about one-half by one-third inch, its long axis being parallel with the course of the ureters. Apparently the retractile power of the ureters when they were severed had helped to pull apart the cut edges of the mucosa. The base of the ulcer was formed by the muscle layer of the bowel. It had healed perfectly and its integrity had not been interfered with by the cutting current at the time of the second operation. The cut ends of the proximal segments of the ureters could be seen in the upper margin of the ulcer. Both emitted water freely within the lumen of the bowel when it was injected into the ureters above the anastomosis.

We were convinced by these experiments that when a wire is looped over the ureters the degree and the duration of obstruction which follows Ferguson's first page operation is both increased and prolonged (Chart I, Curve B), due largely to the accumulation of fecal matter against the coiled ends of the wire, which in the course of a few days usually amounts to a large fecal impaction. Both the weight of the mass and the constant peristaltic effort to expel it caused a constant traction on the ureters. Accordingly, we decided to attempt the operation without the use of wire and employed the following technic.

Group IX: Both ureters were embedded as low as possible in the wall of the rectum and in the lower one-third of their intramural course they were surrounded by a cuff of sheet tin one-half inch wide. This tin was thin enough to be pliable and was also highly magnetic. After healing had taken place we intended to complete the anastomosis by excising the cuff with the aid of a large glass proctoscope with an elongated window on the side. The chief difficulty in such an operation was to locate the cuff at the time of the second stage operation. We anticipated some aid in the use of a magnet if we were unable to locate this body by other means.

EXPERIMENTS

This operation was performed on three dogs (65, 67 and 69). No. 65 gradually lost weight and strength after the first operation and died on the eighteenth postoperative day. The nonprotein nitrogen of the blood had rapidly risen during these 18 days until it had reached 300 mg. per 100 cc. of blood. At postmortem both kidneys were extensively infected. No evidence of dilatation of either ureter was present. The chief finding of interest, however, was that the metal cuff had slipped in the bowel wall and

had come to lie at the upper end of the intestinal incision where the ureters entered the rectal wall, rather than at the lower angle where we had placed it. In that position it must have almost completely blocked both ureters as a result of acute angulation.

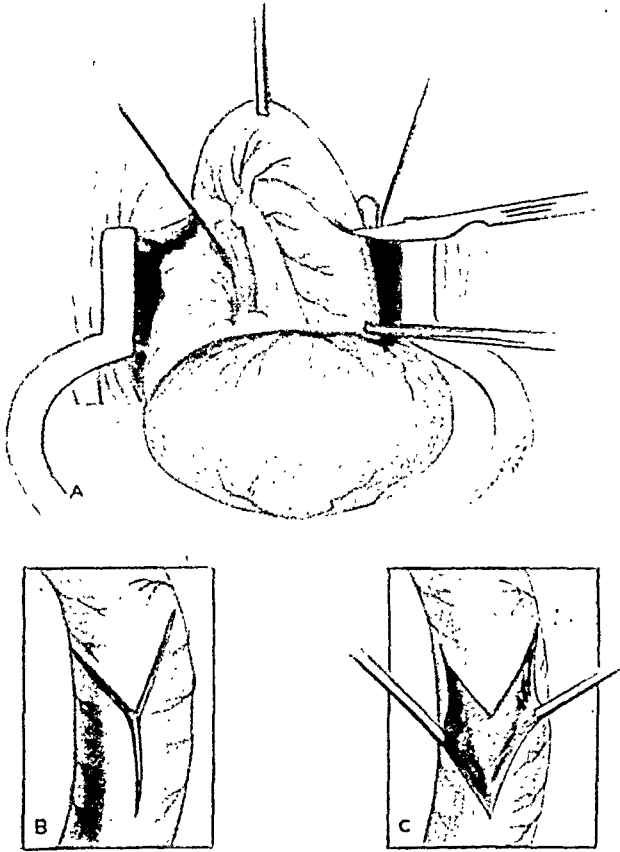


FIG. 1.—A, B, C.

Accordingly, in the other two dogs (67 and 69) we employed a Y-shaped incision (Fig. 1, A and B), placing the metal cuff in the stem of the Y. The V-shaped area of muscularis between the two arms of the Y was not separated from the underlying mucosa

(Fig. 1, C) and the cuff could not slip upward beyond its apex when the wound was closed (Fig. 1, D). No. 67 lost weight after this operation and on the fourteenth postoperative day when the second stage was done, the nonprotein nitrogen in the blood was 240 mg. The metal cuff could be felt with the tip of the index finger. We could detect the impact of the metal against the glass proctoscope. The site of the cuff could also be determined by the presence of petechiae in the mucosa covering it. The

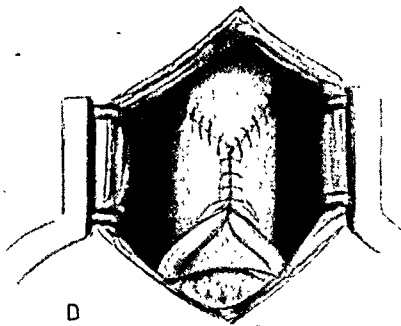


FIG. 1.—D.

bowel was found to be slightly constricted at the level of anastomosis. The metal was successfully removed and at the end of the operation the ends of the ureters hung freely

in the lumen of the bowel. Five days later the dog died. Postmortem revealed hydro-nephrosis and hydro-ureter on both sides. The ureters were unobstructed and draining freely into the bowel. Clearly this dog's death was due to the ureteral obstruction which had preceded the second stage. Dog No. 69 did well after the first stage. The non-protein nitrogen in the blood had risen on the third postoperative day to 80 mg., but by the sixth day it had dropped to 36 mg. On the following day we attempted to remove the metal. It could be felt both through the proctoscope and with the index finger. There was, however, no visible indication of its position and because of this fact we failed in the attempt to remove it. In our manipulations the rectal wall was perforated and the dog died four days later of peritonitis.

CONCLUSIONS

We feel that the following conclusions are substantiated by the above experiments:

(1) If a wire is looped over the ureters at a first stage ureteral operation and left coiled within the rectum for a period of two weeks, it will so impair renal function through ureteral obstruction that life usually is not long maintained. In procedures which elevate the nonprotein nitrogen of the blood to 150 mg. per 100 cc. of blood, though the pressure be subsequently relieved, the animal will not usually survive.

(2) The use of a metal cuff, if properly placed, does not interfere with the healing process and is probably no more injurious to renal function than a wire looped over the ureters. Such a cuff produces no demonstrable direct injury to that portion of the ureter which it embraces. Its removal, however, is too difficult to be practical in human subjects.

(3) Ureters are easily divided by the wire loop and their division in this manner results in an end-to-side anastomosis.

(4) Deaths from renal failure which we have reported following division of the ureters with a wire loop cannot be attributed to renal changes which follow the division, but rather must be regarded as destructive processes within the kidney which have preceded the division.

(5) It is probable that the undesirable effects of the first stage operation can be obviated in man provided the ureters can be catheterized through the cystoscope by draining the kidney pelves during the obstructive period with indwelling ureteral catheters; in patients who cannot be ureterocatheterized preoperatively obstruction may be minimized or obviated by allowing the ends of the wire loops to clear the anus instead of coiling them within the rectum. Infection either in the intestinal wall or in the peritoneal cavity has not occurred as a result of using a wire looped around the ureters with its ends transfixing the intestinal mucosa and fastened together within the rectum. The only objection to its use in connection with Ferguson's first stage operation is its tendency to produce ureteral obstruction. We have been unable to prevent obstruction in dogs by the use of indwelling ureteral catheters for two reasons: first, the dog's ureters are very small and will not admit catheters large enough to adequately maintain urinary drainage for a period of ten days or more; secondly, it is practically impossible to keep catheters in place that long. In man, however,

continuous drainage of the renal pelvis by an indwelling ureteral catheter, size No. 7, is practical. Furthermore, in man the ends of the wire loops can and should be allowed to clear the anus. We believe, therefore, that this technic may prove a safer and simpler method of ureteral transplantation.

Quite recently Brenizer⁶ has described a two stage method of transplanting the ureters in the bowel. His second stage was performed through the rectum with the aid of wires and an electric current, necessitating, therefore, only one abdominal operation. He performed this operation on a woman with irreparable vesicovaginal fistula. So far as we know, he is the first to utilize this plan of ureteral-intestinal anastomosis in the human.

Coffey's second technic has been criticized adversely because the large ureteral catheters, sizes 10 and 12, appear to have caused pressure necrosis of the ureters in certain instances. This criticism would hardly be applicable to ureteral drainage for a shorter interval with smaller catheters.

SUMMARY

(1) In our experience the accepted methods of ureteral transplantation, when applied to dogs, have nearly always been fatal.

(2) The high mortality of the operation is due to peritonitis or obstruction of the ureters at the point of the anastomosis.

(3) Renal infections developing at more or less remote periods following transplantation are in the majority of cases sequelae of obstruction.

(4) Ureteral obstruction results from angulation of the ureter, stricture of the ureter, or from a plug of exudate within the end of the implanted ureter. A brief period of partial or complete obstruction following operation allows the exudate to collect and become viscid.

(5) In these experiments we observed that anastomoses produced by transfixion suture or by any known modifications of that technic were most prone to develop stenosis. It is possible that in some of these cases at least, an adequate fistula was not made at the time of operation.

(6) End-to-side anastomoses, Coffey's first technic, where the cut end of the ureter is brought well within the lumen of the bowel, are least likely to develop stricture.

(7) If stricture follows an end-to-side anastomosis, it is usually because an excess of ureter within the lumen of the intestine has not been maintained following operation. Peristalsis and elasticity of the ureter operate to bring about this postoperative maladjustment.

(8) Ferguson's first stage operation has an exceedingly low primary mortality and is followed apparently by no permanent impairment of renal function.

(9) In order to benefit in the fullest measure by the advantages of Ferguson's first stage, the anastomosis must be completed at a second operation, carried out through the rectum.

(10) At the second stage the ureters should be completely divided so that the late danger of stenosis may be minimized.

(11) To this end, silver wire was looped over the ureters at the first operation.

(12) When wires were looped over the ureters in dogs and allowed to remain in place from 10 to 14 days, they often obstructed the ureters to such an extent that the animals did not long survive their removal.

(13) The tendency of wire to obstruct the ureters in dogs may be due to the fact that it was necessary to leave the ends of the wire fastened together by a shot well within the anus. This allowed the wires to ensnare the contents of the bowel. In time the weight of the impaction plus the efforts of the bowel to expel it by increased peristalsis produced such traction on the wire loop that the ureters could not function.

(14) In the human, where the cooperation of the patient permits the ends of the wire to clear the anus, the tendency to obstruct may possibly be largely removed.

(15) Nevertheless, if this method of transplantation is employed in man, it is highly desirable where possible to drain both kidney pelves while the wires are in place by indwelling ureteral catheters.

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BILATERAL ASEPTIC NECROSIS OF THE FEMORAL HEAD

PROBLEMS ARISING IN A COMPENSATION CASE

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THE case to be presented represents a very interesting problem from the clinical, pathologico-anatomic aspect and, especially, from the viewpoint of evaluating the amount of disability following an industrial accident.

CASE REPORT

A 45 year old man entered the clinic, complaining of pain and stiffness of the right hip. Two years before admission he slipped on wet ground while carrying one end of a long plank. He was knocked down backwards and was struck over the right hip anteriorly. There was immediate pain around the right hip. He walked with difficulty and his superintendent assigned him a lighter job for the remainder of the day. Roentgenograms were not taken but heat therapy was advised. He improved greatly but the pain did not disappear completely. He returned to work in two weeks. After four or five weeks he had to stop working again because of pain in the hip and limp. He was then in bed four or five months. During the winter months especially pain and stiffness in the hip joint were severe. About six months before admission the hip became almost completely rigid, and since that time he has been unable to put his right shoe on. Pain is less marked now and for the last year weather changes have had very little effect. Patient has lost 20 pounds since the accident.

On physical examination, the patient is a well developed, powerfully built man who walks with a marked right-sided limp. The right lower extremity is held in about 25° external rotation, 15° abduction and 10° flexion; only 10° of flexion is possible. There is slight tenderness over the anterior aspect of the hip. No atrophy of thigh.

Patient was admitted for physiotherapy treatment, under which he improved considerably. The pain disappeared almost completely and there was increase of motion (flexion from 165-120°). Patient was then discharged to continue with heat treatment at home. He returned again after one year. There was no improvement, the hip was practically rigid, in marked flexion—abduction and external rotation contracture.

Roentgenograms were taken at different occasions (the earliest six months after accident); they always showed more or less the same, very unusual picture. The head of the femur appeared, on both sides, containing a very dark shadow which on the left was wedge-shaped, the basis of the wedge comprising almost the entire joint surface, the point in the center of the neck. On the right side the sclerotic area involved the subchondral region, but the other part of the head showed very irregular bony trabeculation. Through the upper part of the head of the femur, opposite the roof of the acetabulum, extended an irregular fracture line more or less parallel to the joint surface, separating a slightly flattened lentil-shaped fragment from the other portion of the femoral head. Where the fracture line ended at the joint surface a small spicule of bone protruded into the joint cavity. Otherwise, the joint cavity was of normal width, the joint surfaces smooth, only in its inferior part beginning formation of marginal exostoses could be seen on the ilium on the right side.

From the clinical and roentgenologic findings the diagnosis of a degenerative (hypertrophic) arthritis of the right hip joint was made, developing most likely upon the basis of an intra-articular fracture of the head of the femur. The dark shadow of the femoral

epiphyses was most unusual for hypertrophic arthritis, but was considered as a very pronounced degree of reactive osteosclerosis in the subchondral zones.

Because there was practically no improvement, despite protracted physical therapy treatment, an exploratory operation, followed possibly by an arthroplasty, seemed indicated.

Operation.—The right hip joint was exposed between tensor fasciae latae and gluteus medius. The joint capsule was considerably thickened. It was incised and the head of the femur was dislocated into the wound. It was markedly misshapen; it was enlarged and showed a cartilaginous cover with very pronounced degenerative changes and unevenness. The ligamentum teres was still present and there were marginal exostoses entirely around the joint surface. Eroded areas of the joint surface were relatively scarce. The head of the femur was trimmed to reduce it in size, and here a very unusual picture was

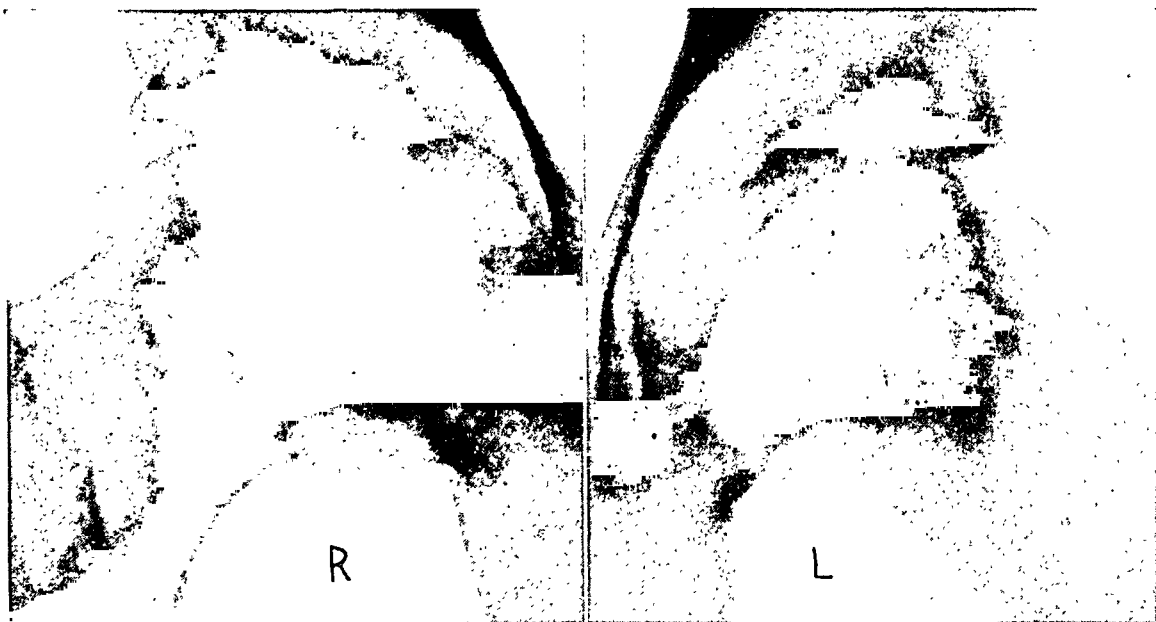


FIG. 1.—Right and left hip joints with dark shadow of epiphysis due to aseptic necrosis. Subchondral fracture line running through upper pole of right femoral head with small spicule of bone, pointing into joint cavity. Resorption of necrotic bone more advanced on the right side. Mild hypertrophic arthritic changes.

encountered. For the greater part, the head of the femur was necrotic. The spongy bone was dense, yellow, and not bleeding. The yellow necrotic areas were surrounded by hyperemic, more porotic portions which were separated from the necrotic bone by a sharp line of demarcation. Almost all of the necrotic bone tissue was removed, together with the joint cartilage. The denuded head was covered with a flap of fascia lata which was also sutured to the joint capsule. The head was reduced and the capsule closed.

The findings at time of operation explained very well the roentgenologic picture. The dark shadow was due to an aseptic necrosis of the epiphysis. Better understanding of the clinical and roentgenologic picture resulted from the histologic examination of the pieces removed from the head.

Pathologic Report.—Received a great number of pieces of the head of the femur; most of them were flat and covered by joint cartilage. Put together, the pieces make up the entire joint surface of the head. The joint cartilage shows marked signs of degeneration and unevenness. It is, however, eroded and replaced by fibrous tissue or fibrous cartilage only in a few places, especially around the insertion of the ligamentum teres. The underlying bone tissue shows essentially two portions: one is very dense, yellow, with occluded marrow spaces; the other is grayish-red, hyperemic, more porotic spongy bone. The demarcation between both portions is usually represented by denser grayish

fibrous tissue. Exostoses have developed at the joint margin, overlapping the old joint cartilage to a considerable degree.

Histologic examination showed the process of reorganization of the aseptic necrosis of the head of the femur in a well advanced stage. In the areas of necrosis the spongy bone is of normal density; it lacks the cellular stain entirely. The marrow spaces are, to the greatest extent, filled by amorphous granular material which contains also a few small fragments of spongy bone. These small fragments came from a fracture space which extends for a considerable length, parallel to the joint surface, through the subchondral bone. The fracture also involves the joint cartilage which shows in several places complete interruption, with overlapping of the cartilaginous fragment ends. Because some of the subchondral bone remained in connection with the joint cartilage, it seems in the roentgenogram as though a spicule of bone was protruding into the joint cavity

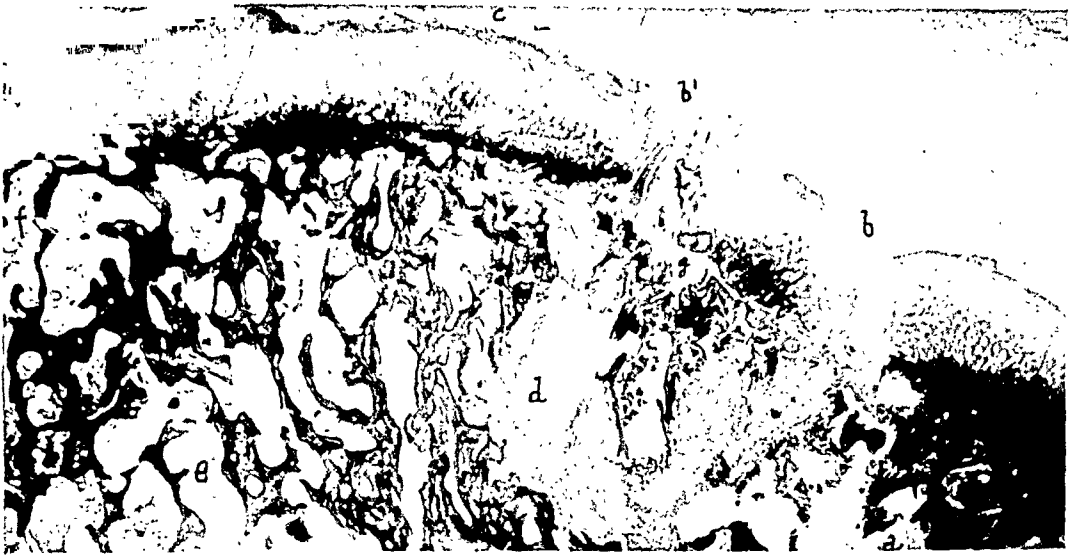


FIG. 2.—Low power photomicrograph through joint surface of the head of the right femur. Area of aseptic necrosis (a) separated from reorganized bone (c) by a zone of fibrous tissue. The reorganization of the bone marrow has led to normal fatty marrow at (f), (b), and (b'). Fracture of joint cartilage with subchondral fracture space (g). Marked degenerative arthritic changes of the joint cartilage at (c) (fibrillation and loss of basophilia).

at the place of overlapping. Along this fracture space which primarily extended through necrotic bone, trabeculae and bone marrow gradually became worn off during weight bearing. Healing cannot take place because of the absence of living tissue. Thus the small fragments first accumulated in the fracture space; here, they became diminished in size and were gradually massaged into the nearby marrow spaces. This led to the dark roentgenographic shadow of the femoral epiphysis.

At the periphery of the area of aseptic necrosis, a zone of reorganization has formed, characterized by loose fibrous bone marrow, relatively rich in vessels and inflammatory cells. Among the latter, lymphocytes are prevalent but plasma cells also are quite frequent. Where the fibrous bone marrow reaches the necrotic fatty marrow, the fatty cells disintegrate. Their fatty content becomes dissolved and may again merge to form larger oil cysts, typically surrounded by large protoplasmatic multinucleated cells of syncytial coherence.

At other places the decomposition of fatty substances leads to irregular calcification. The free fatty acids combine apparently with lime salts of the blood to form calcium salts of fatty acids. In the surroundings of this granular calcification bone apposition takes place also along the surface of the necrotic bony trabeculae. In the first stage this bone formation is very primitive, dark-blue fibrous bone which resembles somewhat the calcification of the necrotic bone marrow. In more mature stages, however, lamellar

bone tissue is found on the surface of the old necrotic bony trabeculae. Considerable but irregular osteosclerosis results thus at the zone of reorganization.

The joint cartilage does not show signs of necrosis. There are, however, many changes of degenerative and hypertrophic arthritis. At the joint margins, but also along the joint surface, the joint cartilage becomes invaded by bone marrow spaces from below. This invasion represents the beginning of a process of enchondral ossification which results in formation of new spongy bone. The zone of provisory calcification is frequently overrun, so that in more advanced stages two layers of calcified cartilage may be found at two different levels: the older one more distant from the joint surface; the more recent one, closer. At the joint margins the process of enchondral ossification leads to typical formation of marginal exostoses. Here, the noncalcified joint cartilage shows proliferation of its cells with gradual transformation of the hyaline ground substance into fibrous cartilage.

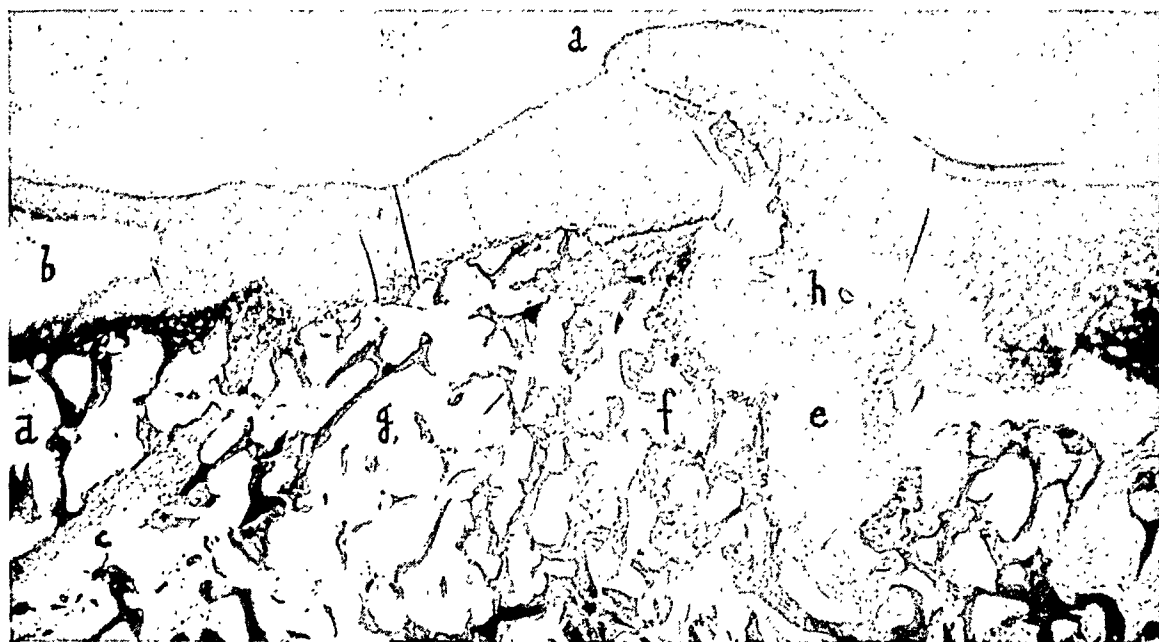


FIG. 3.—Low power photomicrograph through head of right femur. Subchondral fracture line opens at (a) into the joint cavity with overlapping of the fragments of joint cartilage. Fracture space filled with fibrous tissue eroding the joint cartilage from below at (h). Hypertrophic arthritis with formation of exostoses (d) over the calcified layer of old joint cartilage (c). (b) Artificial defect in joint cartilage. (f) Reorganized spongy bone with fibrous bone marrow. Fatty bone marrow at (g).

A fibrous tissue panus may also be seen at the free joint surface, especially at the joint margins and at the site of fracture of the joint cartilage. Here, the fragments have become partially reunited by fibrous tissue which is in part derived from the cartilage itself, from which it had been freed by resorption of the hyaline ground substance.

From these findings we conclude that we have to deal with a case of bilateral aseptic necrosis of the head of the femur. On the right side the process is older and in a more advanced stage of reorganization, but the analogous roentgenogram on the left side proves conclusively that there is the same process present. The patient never complained of the left hip; all his symptoms were centered around the right hip. Bilateral aseptic necrosis of the femoral head is an extremely rare condition in adults. In juveniles it is not so infrequent, in form of a bilateral Perthes' disease. To my knowledge, the only case of a bilateral occurrence (without fracture of the neck of the femur) in an adult was described by me in 1926.¹ The autopsy on a woman, 77 years of age, revealed marked arthritic changes

in both hip joints, resulting from an advanced stage of reorganization of epiphyseal aseptic necrosis. In both femoral heads subchondral fracture lines were present exactly of the same appearance as in our present case. There was no more marked trauma in the history. The question as to etiology had to remain open, the traumatic and embolic factors being in the foreground. The subchondral fracture lines were evidently secondary. They developed gradually, with the resorption of the necrotic bone, and the weakened mechanical resistance of the femoral heads to weight bearing. They represent a typical occurrence in epiphyseal necrosis and are "spontaneous" rather than traumatic fractures (Perthes', Köhler's and Freiberg's disease).

Our present case is a compensation case. The patient claims that his disability started with an industrial accident. A direct trauma to the hip was followed by pain and stiffness. Roentgenograms were not taken until six months after the accident. They showed then, on several occasions, the above mentioned picture. It is quite certain that the trauma suffered by the patient cannot be responsible for the aseptic necrosis of both femoral heads. The patient never complained of the left hip, which shows essentially the same picture as the right. There is only one difference, i.e., in none of the numerous roentgenograms is there present a subchondral fracture line in the left hip. However, it is present in the earliest picture in the right femoral head. The aseptic necrosis evidently preceded clinical symptoms for a long time. It is possible, and this is the only thing which speaks in favor of the patient, that this subchondral fracture of the right femoral head is due to the trauma the patient sustained. The aseptic necrosis, however, evidently in this case without traumatic etiology, preceded the clinical symptoms for a long time. It has to be considered as a spontaneous form of aseptic necrosis which shows that we are still very far from a clear understanding of this peculiar bone pathology. The secondary subchondral fracture is intra-articular and, to a large extent, certainly has led to augmentation of arthritic symptoms; it may even be that the clinical manifestations started with the occurrence of this fracture. On the other hand, it is true that epiphyseal aseptic necrosis *per se* may be followed by quite marked degenerative and hypertrophic arthritic changes, the so called osseous form of arthritis deformans (Axhausen), without occurrence of a more pronounced secondary complicating trauma. Therefore, the patient has to be considered, from the medicolegal point of view, in the same light as a case with metastatic malignancy or with Paget's disease, who sustains a fracture of the affected bone while working. His claim for compensation must be rejected on the basis that his primary bone disease, i.e., the aseptic necrosis, is certainly not due to the industrial accident. The subchondral fracture may be the result of the injury, but since it develops so frequently without it, it must not necessarily be attributed to the trauma. It is to be expected that symptoms similar to those existing on the right side will also develop, sooner or later, on the left side. This will then prove definitely

that the entire pathology in this case is essentially independent of the industrial accident.

We had the occasion recently to observe another, somewhat similar case which on histologic examination proved to be an aseptic necrosis of the femoral head.

Case Report.—A colored man, 31 years of age, complained of pain in the left hip, which came on very gradually. The only thing the patient could offer in explanation was that during his work (butcher) he had to assume a certain position in which his hip tired easily. The hip became stiff but limbered up spontaneously. On physical



FIG. 4.—Aseptic necrosis of the head of the femur in a 31 year old colored man. Irregular osteoporosis by reorganization of the necrotic areas which still appear in normal bony density. Slight narrowing of the joint space.

examination mild flexion contracture with some limitation of motion was found. Laboratory findings were essentially negative except for the roentgenograms which showed an unusual picture of irregular osteoporosis in the femoral head and slight narrowing of the joint space. Physiotherapy treatments followed by immobilization in a plaster case did not afford any relief of symptoms. Biopsy from the head of the femur and the joint capsule was performed, which showed a typical picture of a subchondral aseptic necrosis undergoing reorganization by fibrous bone marrow. There were nonspecific chronic inflammatory changes in the joint capsule, but not more so than could be expected in a case of aseptic bone necrosis.

This case, as in the first one, shows that aseptic necrosis of the femoral head may develop in adults without marked trauma and apparently without any underlying vessel disease. Since we do not know more about the etiology of aseptic bone necrosis, it is to be considered as an idiopathic disease which may lead to considerable functional impairment and its consideration may become of great importance in industrial medicine.

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THE TREATMENT OF OLD UNREDUCED NASAL FRACTURES

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RECENT fractures of the nose have been exhaustively considered, but the surgical management of old unreduced nasal fractures has been dealt with sparingly. Although this type of fracture is classified as a minor injury, its common occurrence, the interference with respiration, together with the unsightliness produced, merit more careful consideration, especially as its correction can only be accomplished surgically.

This paper is limited to the treatment of unreduced nasal fractures 6 to 12 months after the injury, in which part or all the nasal elements have settled in abnormal relations, and where the original form of the nose can be restored only by a series of procedures which include mobilization, relocation, and maintenance in a normal position.

TREATMENT.—Anesthesia. The field of operation is walled off with 30 to 40 cc. of a 1 per cent solution of novocain with the addition of 10 drops of a 1-1000 solution of adrenalin to each 30 cc. Three intradermal wheals are raised, one at the junction of the bony and cartilaginous dorsum and one on the side of each ala. A preliminary freezing with ethyl chloride allays the apprehension occasioned by the initial hypodermic. The infratrochlear, supratrochlear and external nasal branches of the ophthalmic supplying the root of the nose, the glabella, and lateral walls are infiltrated by inserting a long needle into the dorsal wheal, the solution being delivered slowly as the needle advances toward the root of the nose. It is carried laterally to the junctions of the nasal bones with the maxillae, where infiltration is continued under the periosteum. The external nasal branch of the infra-orbital supplying sensation to the skin on the side of the nose and mobile septum may be blocked at the infra-orbital foramen located $\frac{1}{2}$ cm. below the midpart of the lower margin of the orbit and about $2\frac{1}{2}$ cm. from the midline of the face on a line with the pupil of the eye. The nasal branch supplying the mucous membrane and skin of the alae, apex of the nose, columella and floor of the anterior nares is infiltrated by inserting a shorter needle into the lateral wheal and working from the apex down to the alar base. The septum is anesthetized by the surface application of pledgets of cotton wrung dry of a 10 per cent cocain solution applied against the septum.

TECHNIC.—Once the diagnosis of the displacement has been made and the reduction to be attained has been settled in the mind of the operator, the procedure may be followed by the drawings and is both simple and rapid. The operative manipulation should not last more than an hour, and the period of hospitalization should not exceed three or four days.

Approach to the Nasal Framework.—The tip of the nose is retracted with the left thumb and index finger, and a double-edged scissors is intro-

duced into the left vestibule between the upper and lower lateral cartilages about midway between their anterior and posterior margins, care being taken to incise the aponeurosis connecting the two cartilages without injuring them. The advantage of this incision is that it follows anatomic raphés and prevents severance of the angular and septal branches of the superior labial artery. The point of introduction of the scissors may be easily located by the anatomic shelf formed by the lower margin of the upper lateral cartilage when the tip of the nose is retracted, the incision being made along the lower margin of this shelf. The blades of the scissors are separated for a distance of $1\frac{1}{2}$ cm. (Fig. 1).

Through this intranasal incision a scissors curved on the flat to accommodate itself to the convexity of the nasal curve, beveled to protect the skin, and sharpened on both sides, is carried beneath the skin over the upper lateral cartilage but not over the nasal bone. By opening the scissors the skin is undermined laterally to the nasofacial fold and medially to the dorsum of the nose (Fig. 2). The same procedure is repeated on the opposite side through a similar incision. The bleeding at this time is controlled by introducing tampons wrung out of a 1-1000 adrenalin solution.

Separation of the skin from its underlying structures is necessary to afford freedom for redressment. It should be completely separated over the line of fracture. It is advisable not to carry the separation much beyond the malpositioned bones because the trauma of extensive separation results in delayed convalescence. Due to the inherent elasticity of the skin it readily readjusts itself to the reconstructed nose.

After detachment of the skin from its subjacent structures, the periosteum next demands consideration in order to expose the bone. Through the initial incision a small periosteal elevator is introduced, engaging the periosteum at the caudal margin of the nasal bones. With a to and fro movement of the elevator it will be found that the periosteum strips easily from the bone (Fig. 3).

Following the separation of the soft parts and in order to obtain a better exposure, a scalpel is introduced through the initial left incision, passed directly over the anterior margin of the septal cartilage, turned at right angles to follow the course of the caudal extremity of the septum, and brought out through the incision on the opposite side (Fig. 4). The membranous septum is cut through about half way to the nasal spine. Completion of the incision is facilitated by replacing the knife by a scissors and cutting the membranous septum down to the nasal spine. With the nasal arch exposed there are many expedients, each dependent upon the nature of the deviation in the elements of the framework.

Management of the Osseous Structures.—(1) Should the nasal dorsum show irregularity due to ossification in an overriding position, the dorsal line must be straightened. A nasal saw is introduced through the initial incision and placed flush with the irregularity at the exact level at which the profile is to be reduced. The thumb and forefinger of the left hand are

placed on the side of the nose in order to protect the skin and prevent the saw from slipping. With a few vigorous thrusts of the saw the bony and cartilaginous elements and perpendicular plate of the ethmoid are cut through

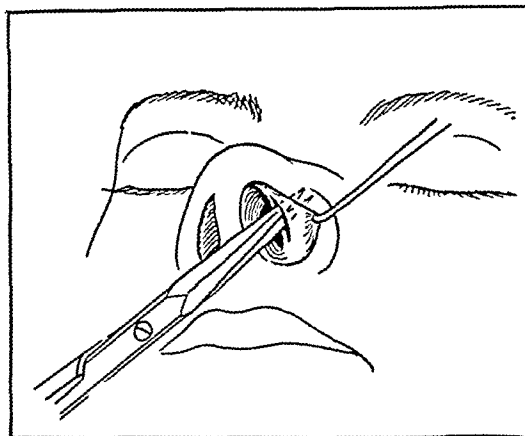


FIG. 1.—Incision between upper and lower lateral cartilages.

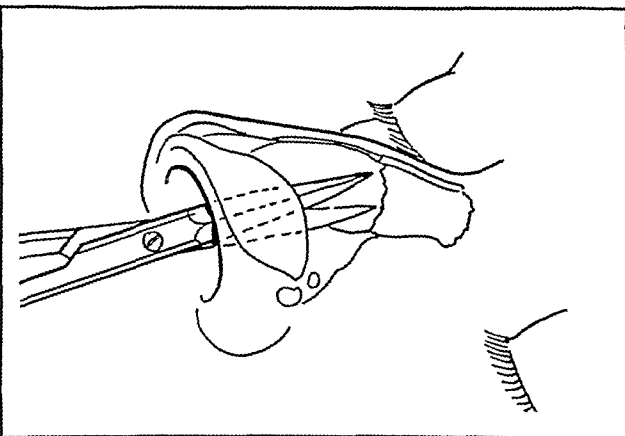


FIG. 2.—Separation of the skin from subjacent structures.

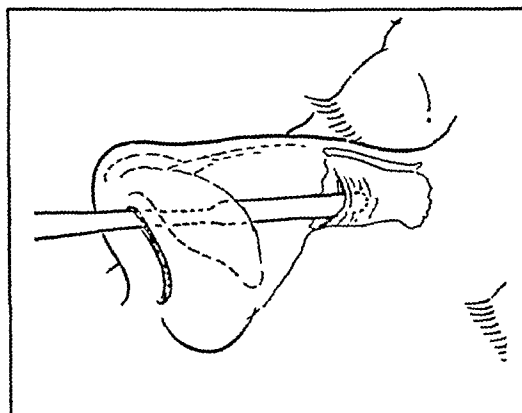


FIG. 3.—Separation of the periosteum from the nasal bones.

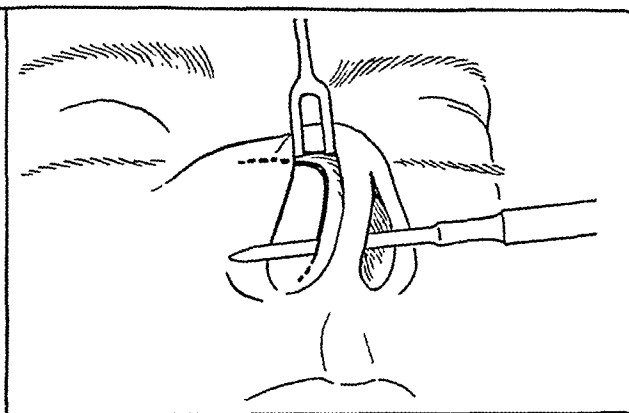


FIG. 4.—Course of the scalpel in transfixion.

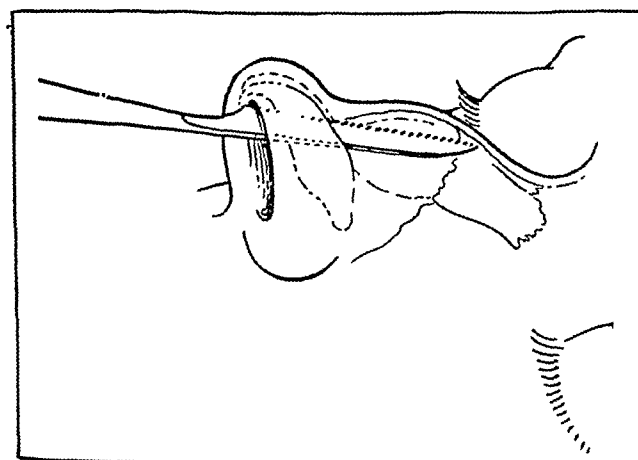


FIG. 5.—Saw reducing the irregularity to straighten the dorsum.

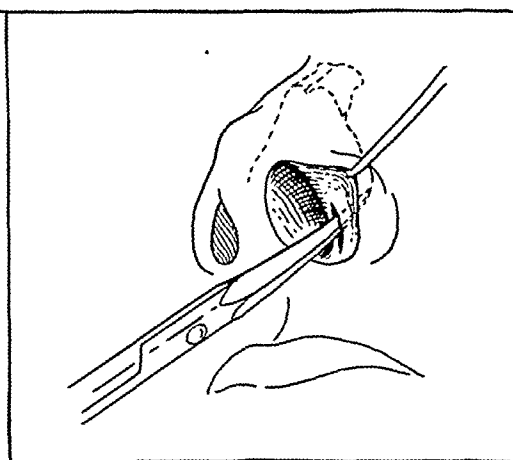


FIG. 6.—Vestibular incision for the lateral osteotomy.

(Fig. 5). The saw is removed and the same procedure is repeated on the opposite side. A knife is introduced under the cut bony section and is drawn downward to the tip of the nose, thus completely freeing all remaining attachments. After removing the knife, the section of bone and cartilage

so liberated is extracted with a stout forceps. All irregularities of the bone and cartilage which now remain are smoothed off with a rasp.

The excision of a stratum of bone to eliminate the irregularity results in a flat triangular defect whose apex points toward the nasal arch, the lateral walls standing out vertically on the maxilla. This defect must now be closed. A double-edged scissors is thrust into the mucosa of the vestibule at the nasobuccal junction and forced through the soft tissues until the pyriform opening is felt (Fig. 6). The skin and periosteum are elevated as before. The saw is introduced beneath the periosteum and is placed in the nasofacial groove, the base of the saw being positioned at the outermost margin of the pyriform opening and the apex resting midway between the orbit and the glabella (Fig. 7). The position of the saw is maintained with two fingers of the opposite hand. Then with an up and down movement

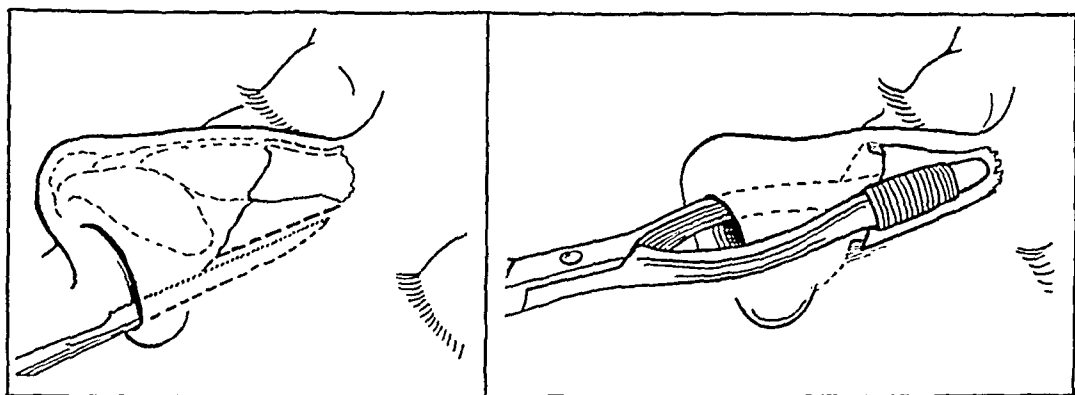


FIG. 7.—Incision for the lateral osteotomy.

FIG. 8.—Incised bone grasped and with a rotary movement nasofrontal suture is separated.

the bone is sawed through about two-thirds of its thickness, being careful not to pierce the mucosa.

At this stage a Walsham forceps is employed. The outer larger blade (covered with a rubber tubing to prevent injury to the skin) is applied to the outer lateral surface of the nose and the inner smaller blade is introduced into the nasal fossa and held against the under surface of the incised bone (Fig. 8). By a gentle rotary movement the narrow articulation at the nasofrontal suture is separated. So freed, there is no restriction to shifting the bony lateral walls obliquely to the midline, eliminating the dorsal broadness following removal of the irregularity and raising the bones to a degree necessary to reestablish the line of the arch. The mobilization is not considered complete until the nose will remain in the proper position after reduction without support.

(2) It has been demonstrated in the foregoing that where the excessive width of the bridge follows the removal of irregularities, sufficient space has been created along the dorsum for the nasal bones to be shifted to a more central position, and this is accomplished by mobilizing the frontal process of the superior maxilla; but in cases where the abnormal width follows a traumatic separation of the nasal bones without irregularities, before

the nasal bones can be narrowed the spring of the nasal arch much be broken. This is accomplished by introducing a saw into the initial incision and cutting the nasal bone on each side of the osseous septum at the junction of the anterior and lateral aspects of the osseous arch, sawing diagonally toward the nasal process of the frontal bone. After performing the lateral osteotomy through the frontal processes of the superior maxillae in the manner already described, the bones can be brought into a central position, thereby narrowing the bridge (Fig. 9). Traumatic exostoses of the nasal bones or frontal processes of the superior maxillae are planed off with a chisel introduced into the intercartilaginous incision.

(3) Where the force has been applied from in front with impaction and depression resulting in the traumatic saddle nose, the method of correction will depend upon (a) the amount of depression, (b) the existence of cicatri-

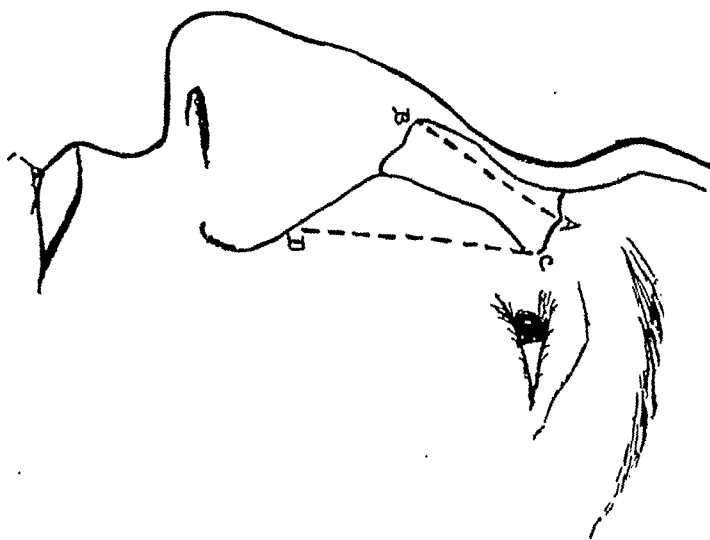


FIG. 9.—A-B line of saw cut on each side of dorsum to break spring of nasal bones. C-D lateral incision to mobilize fragments.

cial tissue, and (c) whether or not the deformity involves the bony or the cartilaginous vault, or both.

Reconstruction of the dorsum by readjustment of the nasal structures already present is the ideal procedure. A slight degree of depression of the bony dorsum may be corrected by an osteotomy of the frontal processes of the superior maxillae. After separating the bones at the nasal and fronto-nasal sutures, the lateral walls are elevated somewhat, thus overcoming the slight depression.

Correction of a moderate depression of the upper cartilaginous vault may be accomplished by separating the upper lateral cartilages from the maxillae and from the septal cartilage, raising them to the required height, and fixing them by a suture placed below their anterior margins, the depth of the suture depending upon the amount of elevation necessitated. Or, the defect may be filled in by pieces taken from the upper or lower lateral cartilages. When material for reconstruction of the arch is not available in the immediate vicinity it may be obtained from cartilage of the ear or rib, depending upon the amount required.

Measurements are taken from the infraglabellar region to the nasal tip and from the tip to the spine of the superior maxilla. The precise length and width of the cartilage required is thus determined. A piece of cartilage indicated by the measurement is removed from the seventh, eighth, and ninth rib cartilages where they spread into a wide plaque. It may comprise the entire thickness of the cartilage or only a part, in which case the excision is facilitated by the use of a woodcarver's chisel (Fig. 10). As soon

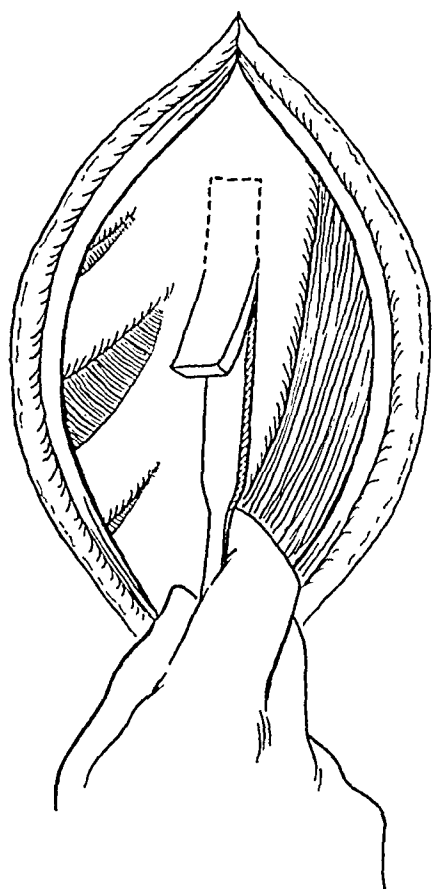


FIG. 10.—Removal of rib cartilage with chisel.

as the cartilage is removed it is shaped to fit the defect and inserted through the original incision (Fig. 11 (a) and (b)). Circumstances may call for modification in the technic. For example, a scar over the bridge may limit the possibility of undermining the tissues in order to prepare a bed for the transplant. In this case the cartilage may be introduced externally through the opening made by excision of the scar.

(4) When the blow has been applied laterally and results in a shifting of the dorsum from the midline of the face, in order to bring the nose into a median position room must be created by removing a triangular section of bone from the broad, concave side so that the narrow convex side may be shifted into a median position and so straighten the dorsum. A lateral osteotomy is performed in the manner already described except for a triangular osteotomy on the concave, or wide side (Fig. 12). The size of the triangle should equal the angle of deviation from the normal. Before the triangular piece of bone can be removed it will be necessary to separate the

mucosa from its under surface. The triangle of bone now freed is grasped with a pair of stout forceps and removed.

With both thumbs on the convex side of the nose (protected by a gauze pad) and the fingers placed against the opposite zygoma the nose is forced into the space created by the removal of the triangular section of bone. Fracture at the nasofrontal suture takes place through the force applied to the convex side. It is important that not only the nasofrontal suture be fractured but also the perpendicular plate of the ethmoid in order to avoid the tendency to recurrence of the deformity.

The Upper Lateral Cartilages.—After the bony arch has been repositioned in its normal location it will be found that the upper lateral cartilages require attention. With the aid of a retractor they may be inspected. If they are widened as a result of the traumatic separation of the nasal bones a strip of cartilage is resected close to the dorsum sufficient to correct the deformity.

They are then replaced in their proper anatomic locations and immobilized by one or two catgut sutures (Fig. 13). They may be thickened or buckled from chondritis, in which case they should be reduced by shaving with a sharp scalpel.

The Lower Lateral Cartilages.—The same trauma that produced the nasal

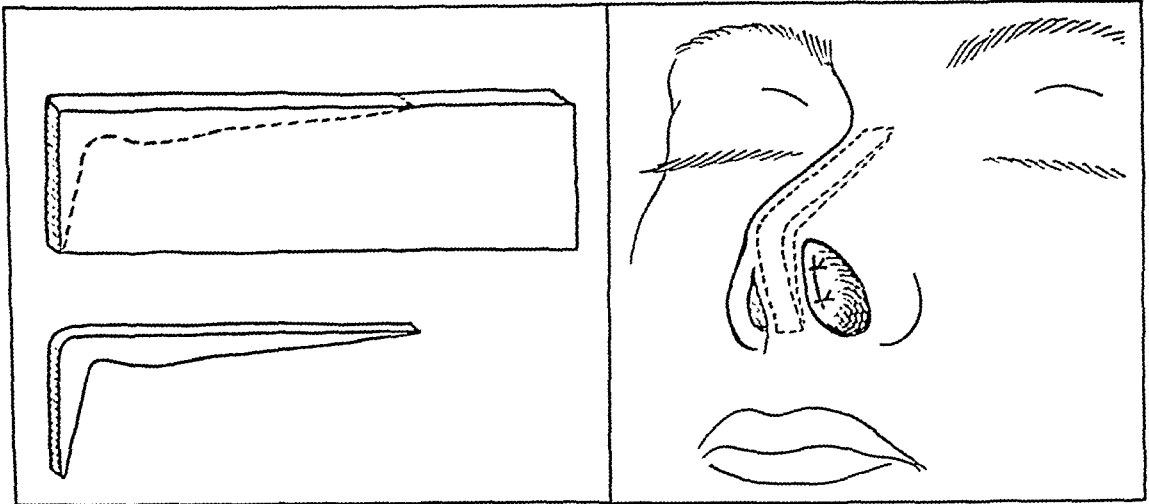


FIG. 11A.—Modeling of cartilage.

FIG. 11B.—Cartilage in place to overcome the saddle.

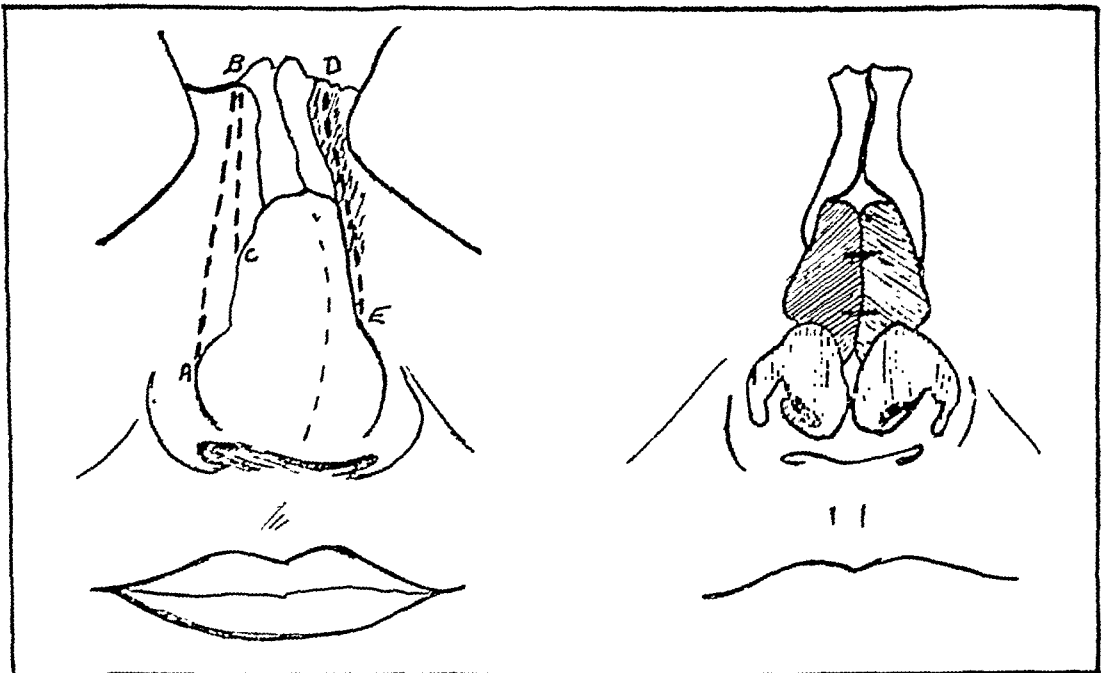


FIG. 12.—A-B-C—Triangular osteotomy on concave side to create room to shift nose into a medial position. D-E—Saw cut for lateral osteotomy.

FIG. 13.—Upper lateral cartilages brought into the midline and immobilized by two catgut sutures.

fracture may be expected to bring about various fractures and displacements in the lower cartilaginous vault. The angles of the lower lateral cartilages produce the curve at the tip of the nose. They may be widened, producing a wide tip. They may be separated, producing a cleft tip. One or both of the cartilages may be hypertrophied, buckled or displaced, producing a twisted tip. These cartilages must now be treated in order to harmonize with the balance of the reduction. The method employed is as follows:

An incision is made in the vestibule just below the inferior margin of the

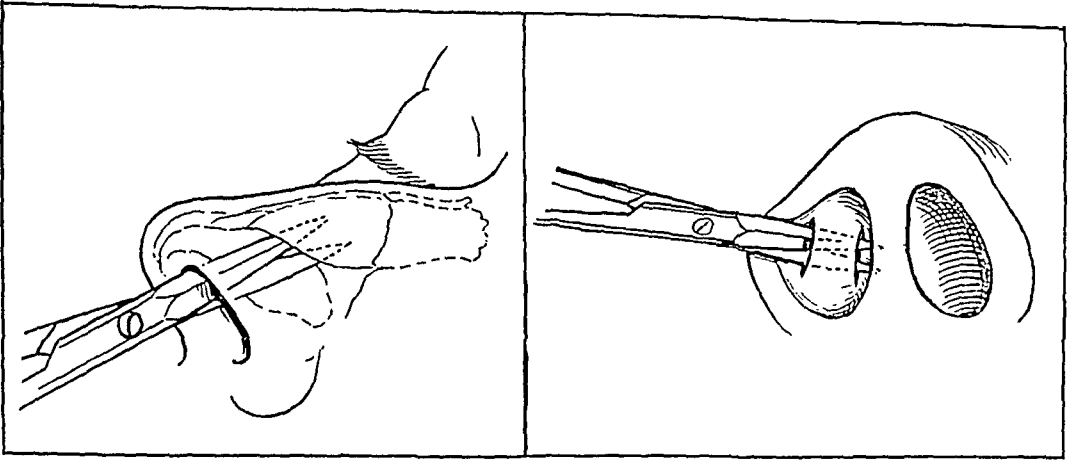


FIG. 14.—Exposure of the lower lateral cartilages (separation of external skin).

FIG. 15.—Exposure of lower lateral cartilages (separation of vestibular skin).

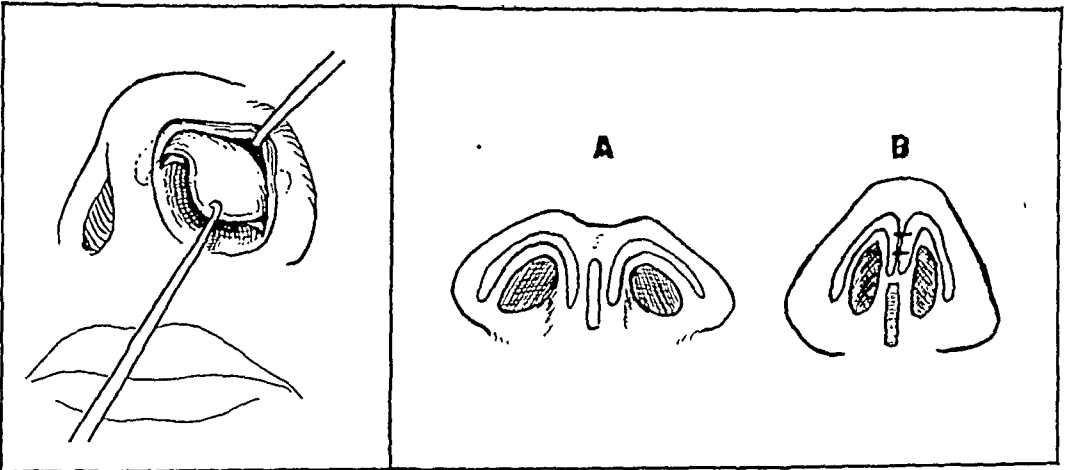


FIG. 16.—Delivery of lower lateral cartilage.

FIG. 17.—(A)—Dislocated lower lateral cartilages. (B)—Lower lateral cartilages brought together and sutured.

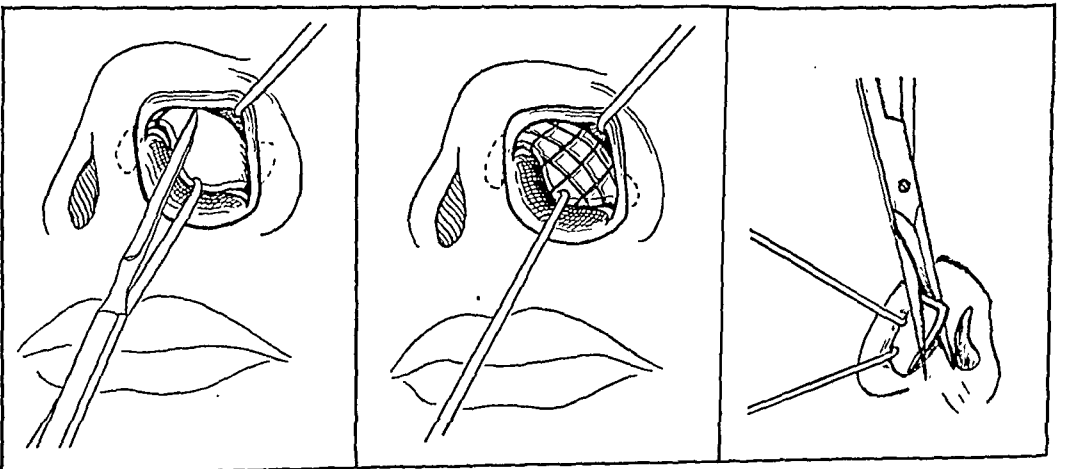


FIG. 18.—Removal of angle to diminish width.

FIG. 19.—Ribbon incision to remove spring of cartilage.

FIG. 20.—Excision of the caudal end of the septum to reduce the length of the nasal pyramid.

lower lateral cartilage. The double-edged scissors mentioned above is introduced into the incision and brought out through the initial intercartilaginous incision, the scissors lying between the external skin and cartilage (Fig. 14). By opening the scissors the tissues are separated laterally to the posterior termination of the alar crus and medially to the septum. The cartilage is also freed from the skin lining the vestibule by the same procedure except that now the scissors lie between the cartilage and the vestibular skin (Fig. 15). Being so freed, the cartilage is withdrawn from the vestibule by a single-hook retractor and dealt with as the pathology may indicate (Fig. 16).

If the angles are separated, they may be brought together and held in place by a suture (Fig. 17, (a) and (b)). If they are too wide, a strip of cartilage is removed from the angle (Fig. 18). The length and width of the excision will be governed by the extent of the reduction it is required to make. The separated parts of the lower lateral cartilage fall into the midline and the reduction of the width of the tip of the nose equals the combined width of the sections of cartilage removed. If the cartilages are hypertrophied, buckled or displaced, this traumatic pathology may be overcome by shaving or cutting them in a ribbon formation to destroy their spring, and repositioning (Fig. 19).

The Septum.—The operative procedure as applied to the septum must be dictated by the conditions found. The problem is to restore the septum as a partition in the median line causing no occlusion of the air passages; to relocate the caudal margin on the floor of the nose in order to give form to the columella; and to bring the anterior margin into a straight line so as to project the dorsal margin at an angle of 30° from the face.

Frequently the septum springs back into the correct position when the nasal arch has been repositioned without further manipulation. But should excision be necessary it may be done in the usual manner, care being taken to leave sufficient buttress to maintain the outline of the nose. A submucous resection should not be performed until the bony and cartilaginous arches have been reestablished; otherwise it may be found that when the dorsal irregularities are excised there is not sufficient support for the dorsum.

Occasionally a blow applied from in front or from the side may separate the upper lateral cartilage from its nasal attachment or fracture the body of the septum with downward displacement, the interval between the separated parts being replaced by organization. This results in elongation of the nasal pyramid. Shortening may be easily brought about in the following manner: The columella is retracted to one side, exposing the lower end of the septum through the nostril. The caudal ends of the lateral cartilages are separated from their attachments to the septum. The lower end of the septum is steadied with a forceps and as much of the exposed part as desired to produce the necessary shortening is excised with scissors (Fig. 20). After shortening the septum it will be found that the upper lateral cartilages are too long and protrude through the original incision. The protruding portion is excised with a curved scissors in such a manner that the edges of the incision again fall into apposition. The whole procedure is terminated by attaching

the columella to the cut end of the lower edge of the septum. A suture is passed $\frac{1}{2}$ cm. below the anterior edge of the septum, the needle passing through the mucosa and cartilage on both sides, through the columella, and



FIG. 21.—Traumatic separation between osseous and cartilaginous dorsum with separation of the upper and lower lateral cartilages. Front and side views.

tied. A second suture is passed in a similar manner just above the nasal spine and through the columella.

Immobilization.—If the nasal arch has been properly mobilized and set, theoretically, splinting is not necessary as there are no muscles capable of

causing redisplacement; but practically, for the first 48 hours it is desirable to put on a Stent dressing to offset the possibility of disturbance by the patient in the early postoperative period. At the end of 48 hours the splint is



FIG. 22.—Fracture with union in an overriding position.



FIG. 23.—Fracture of the septum with a dislocation backward.

discarded, the xeroform packing is removed, and the nostrils cleansed of incrustations with hydrogen peroxide. The nose is kept lubricated with sterile albolene. The patient is allowed to sit up in bed on the third day, discharged on the fourth day, and is instructed to return to the hospital for the removal of the two sutures on the fifth or sixth day.

DISLOCATION AND ELONGATION OF THE LONG HEAD OF THE BICEPS BRACHII*

AN ANALYSIS OF SIX CASES

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DISLOCATION and elongation of the tendon of the long head of the biceps brachii were mentioned as belonging to the symptom-complex previously described.²⁹ This lesion is supposed to be rare unless accompanied by severe injuries to the shoulder girdle. Many cases found at autopsy have been reported in the literature.^{1, 5, 12, 16, 22, 63, 67} Numerous others have been recorded as having been seen clinically,^{3, 13, 17, 20, 30, 34, 39, 46, 50, 52, 69} but not operated upon. Up to the beginning of this century the opinions of the various authors have frequently been in disagreement, some citing cases which, without doubt, were clinical instances of traumatic simple luxation of the tendon^{13, 17, 19, 20, 24, 30, 31, 32, 34, 39, 40, 46, 50, 52, 53, 54, 65, 68, 69, 70} and others doubting or denying such luxation altogether,^{4, 26, 35, 41, 44, 51, 55, 58} but conceding the possibility of a dislocation, the result of chronic arthritis^{1, 5, 12, 16, 21, 63, 64, 67} or a complication of other severe lesions (fracture, dislocation, *etc.*) of the shoulder.^{32, 40, 44, 46}

Commenting on the divergency of opinions of the cases reported, White,⁷⁰ in 1884, stated: "Although for more than 100 years cases of supposed luxation of the tendon of the long head of the biceps muscle have been reported or alluded to by surgical writers, yet they have been so poorly observed or so carelessly described, that they fail altogether to carry conviction, the one case which possesses any strong element of probability being itself open to reasonable doubt."

Meyer⁴⁸ and his associates have found over 50 cases of marked dislocation of the tendon of the long head of the biceps and many others of lesser degree in the dissection of 1,000 arms. Some of these were bilateral. I have had four clinical cases, one successfully operated on† and three under observation. In addition I have analyzed two other cases through the courtesy of Dr. Edward Bull.¹¹

Literature.—In a complete review of the literature I find no mention of an operation having been performed for the relief of this condition. It has been an alluring subject for thought and discussion, nevertheless, and has arrested the attention of some of the greatest surgeons from the time of Hippoc-

* Read before the Western Surgical Association, St. Louis, December 8, 1934.

† This was in 1926 and as far as I have been able to determine is the first uncomplicated case reported of an operation to relieve this condition.

rates, 59 of whom have recorded their opinions. Because of the length of this most interesting history, I have placed it as an appendix to this report.

Anatomic Considerations and Causes of Dislocations.—A consideration of the anatomic structures which form the intertubercular sulcus (bicipital groove), and the course of the tendon within the sulcus and the capsule, readily reveals that the direction of the tendon varies with the position of the arm



FIG. 1.—Portion of a right humerus with a supratubercular ridge marked X. This bony ridge extends obliquely forward and downward from the region of the articular cartilage to the upper and dorsal portion of the lesser tuberosity. As the surface of the distal extremity of this ridge is on a level with the surface of the latter, and since the tendon plays on it much as the tendon of the peroneus longus plays on the trochlea of the cuboid, its rôle in dislocation is plainly evident. In a study made by Cilley (unpublished) it was present in 17.5 per cent of 200 humeri. (I am indebted to Dr. A. W. Meyer, Professor of Anatomy, Stanford University, for this photograph and the explanation of it.)

(Figs. 1, 2, 3). With the arm at rest, Bera⁶ has pointed out, "the tendon is almost horizontal in its intra-articular course and has, in the groove, a vertical direction; its course follows the lines of a right angle with rounded angle at the level of the lesser tuberosity, on the slope of which it rests to be reflected and to slide at the contraction of the biceps. The angle formed by the intra-articular and extra-articular portions of the tendon varies, and according to the different attitudes and positions of rotation of the arm, the tendon is re-

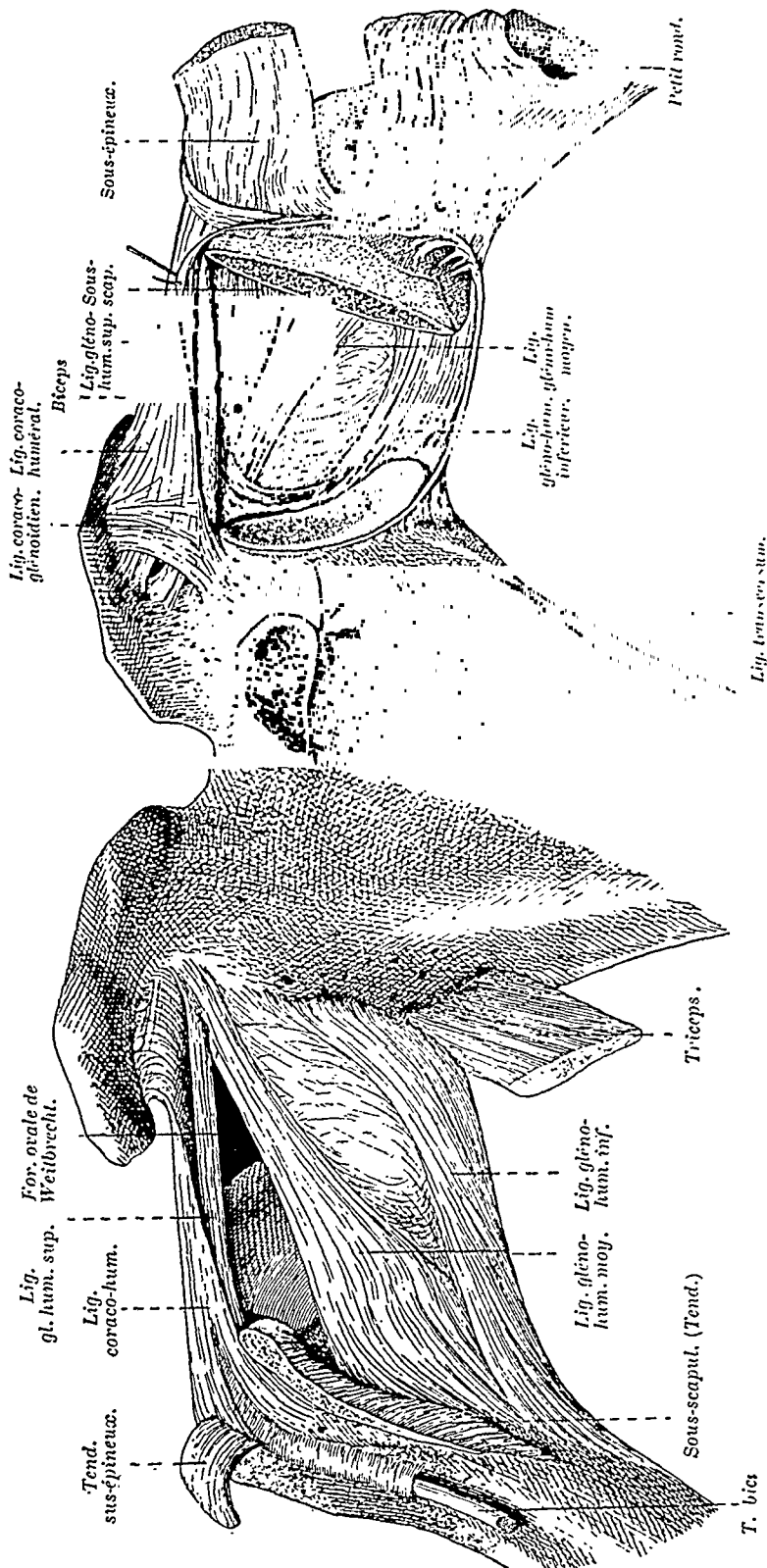


FIG. 2.—Anterior view of shoulder joint showing relationship of tendon of long head of the biceps to articular capsule. (From Poirer's and Charpy's Human Anatomy.)

FIG. 3.—Posterior view of the shoulder joint showing relationship of the tendon of the long head of the biceps to the articular capsule. (From Poirer's and Charpy's Human Anatomy.)

flected on either tuberosity or against the transverse humeral ligament which forms the roof of the osteofibrous tunnel of the bicipital canal.”*

On the other hand, the head of the humerus has a rounded and polished surface. The tendon curves over it anteriorly and mesially, and at that point it broadens and flattens out. This is an anatomic and a physiologic factor for its dislocation. The tendency to dislocation is further increased by the fact that contraction of the biceps muscle puts the tendon of the long head under tension and the curvature, which the tendon has over the head of the humerus when the arm is more or less adducted, tends to straighten out, “while the head of the humerus is pushed downwards and backwards.”⁴⁷

According to Meyer,⁴⁷ “In all normal joints there are three, and there may be six, factors which favor dislocation of this tendon: (1) the normal course of the intracapsular portion of the tendon and its relation to the humeral head; (2) the much greater width of the proximal portion of the tendon; (3) the fact that the anterior wall of the sulcus which is formed by the lesser tuberosity normally acts as a trochlea for the tendon in the usual position of medial rotation; (4) a supratubercular ridge may be present; (5) the capsular attachment may be weakened by intracapsular bursae, and (6) the capsular attachment to the anatomic neck in the region proximal to the lesser tuberosity may be restricted.”

He believes that “the tendency to dislocation of this tendon, which exists in all normal shoulder joints, is opposed primarily by the attachment of the articular capsule in the region proximal to the lesser tuberosity” and by the medial ridge of the sulcus which sometimes is very steep. He does not agree with most anatomists that the transverse humeral ligament plays an important rôle in preventing this dislocation and has accumulated conclusive evidence, in his dissections, that the partial dislocation of the tendon of the long head of the biceps brachii is a surprisingly common condition. In a number of his specimens the capsule is entirely intact though it has stretched, forming a sling around the dislocating tendon so that the tendon lies partly or wholly upon the lesser tuberosity, using it as a trochlea (Figs. 4 and 5). To quote Meyer, it is interesting that “since the surface of the lesser tuberosity is normally rough, the under surface of the tendon will show evidence of wear unless protected by this capsular sling, the deeper portion of which forms a cushion for the tendon. If this wear progresses, it weakens the tendon and may ultimately destroy it to the extent that a rupture may follow.”

Another factor which undoubtedly plays an important rôle in the dislocation of the tendon was first described by Bera,⁶ who showed that a malforma-

* As Meyer⁴⁷ has said: “When the arm is in slight lateral rotation, the under surface of the tendon lies fully on the floor of the sulcus; but as lateral rotation is increased its anterior margin is forced against the anterior wall of the sulcus, especially that portion formed by the lesser tuberosity and the capsular attachment proximal to it. In medial rotation, on the other hand, the anterior wall of the sulcus and the adjacent capsular attachment become the surfaces which the tendon uses as a trochlea, while its dorsal margin is forced against the dorsal wall of the sulcus.”

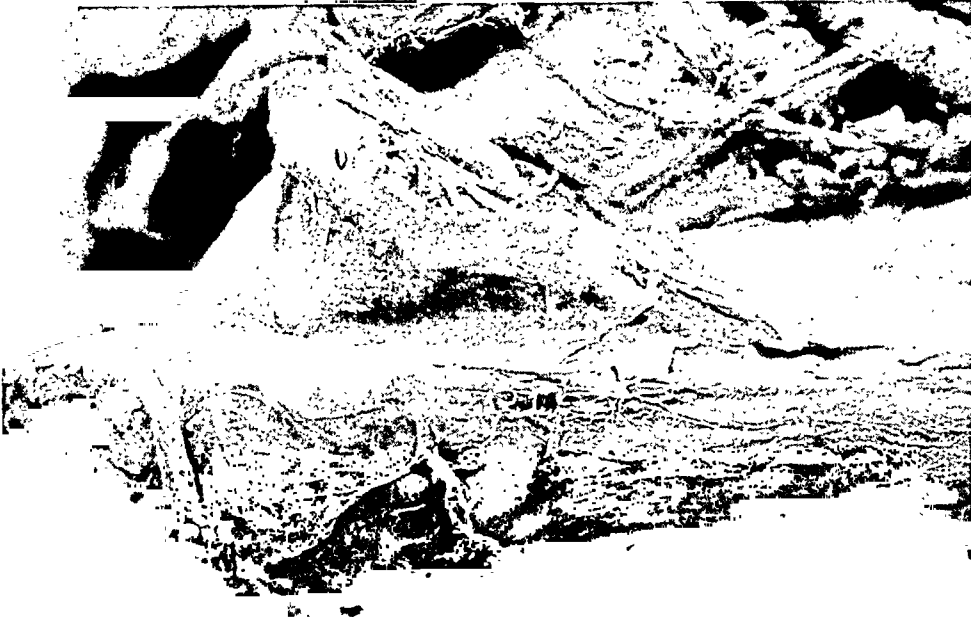


FIG. 4.—This shows how clearly the yielding of the capsular attachment in the region of the lesser tuberosity permits the long head to be dislocated anteriorly or downward, and explains the relaxation of the tendon often spoken of as the elongation of the tendon. (Kindness of Dr. A. W. Meyer, Professor of Anatomy, Stanford University.)



FIG. 5.—A right humeroscapular articulation with the tendon reflected anteriorly to reveal its bed. The proximal portion of the intertubercular sulcus is seen to the left of the new bed of the tendon. This tendon, which lies in a capsular sling, had passed practically over the lesser tuberosity but still occupied the sulcus distal to the intertuberosal region. (Kindness of Dr. A. W. Meyer, Professor of Anatomy, Stanford University.)

tion or a localized osteitis reduces the volume of the lesser tuberosity and favors the luxation of this tendon. He also believed that this tendon can be dislocated by a violent muscular contraction, particularly in the presence of preexisting arthritis. When this tendon slips over the lesser tuberosity the tension of the muscle is immediately lessened and we have what is known as the typical relaxed tendon, producing the classical bicipital syndrome.

Arthritis, however, is not always a preexisting factor in dislocation, as proved by Meyer. In a remarkable specimen revealing a bilateral dislocation of the tendon, that of the right arm was much farther luxated than the left, it having passed completely over the lesser tuberosity, while the tendon of the left arm had luxated only to the top of the tuberosity. Consistent with the condition found in other specimens of dislocated tendons of the long head of the biceps, there was not the slightest evidence of arthritis.

Types of Dislocation.—Bera⁶ also pointed out that, while the tendon may and does "dislocate forward, it may also dislocate posteriorly, completely or partially. The complete dislocation involves the opening of the bicipital groove and the local detachment of the articular capsule. The violence capable of producing this disorder will more likely produce the rupture of the tendon or the dislocation of the shoulder. But these cases of posterior dislocation are not related to the bicipital syndrome." According to the onset, the dislocation may be acute, gradual, or recurrent. The acute and recurrent types are rapidly disabling, for the period of their duration, while the gradual type may not be disabling at all except for a more or less vague discomfort in the shoulder which often is interpreted by the patient and the physician, as being rheumatic in origin.

Mechanism of Production.—The mechanism of production of the acute and recurrent types of luxation is brought about by external rotation and abduction of the arm over 90 degrees, in which position the tendon is reflected more, over and against the attachment of the articular capsule in the region of the lesser tuberosity. According to Borchers,⁸ the production of the osteophytic outgrowths in and around the bicipital groove, the result of arthritis, may be such that the groove will be filled and thus the tendon becomes mechanically dislodged. Gurlt³³ reports one such case of dislodged tendon. Meyer⁴⁸ discussed the various factors which favor a dislocation of the tendon and came to the conclusion that it may be the result of occupation.

Symptoms.—Symptoms of a dislocated tendon are variable and depend on the onset and type. In most cases they are similar to those of a ruptured biceps tendon.²⁹ The onset is usually acute. There is pain in the region of the bicipital groove, which may radiate down the muscle. This pain is increased on external rotation and overhead extension. There is also weakness of the arm. The pain and the weakness may be so marked that the function of the limb is very much impaired.

If the dislocation has been complete, the tendon of the long head of the biceps has, according to Bera⁶ "a direction more inclined than usual in regards

to the axis of the body," and "with the arms horizontally, in cross-like fashion, the direction of the external bundle of the biceps ends in front and not over the glenoid cavity." This sign may be visible, of course, only in thin, muscular persons.

An apparent elongation of the long tendon may be seen, evidenced by a slight flabbiness of the muscular belly which may be lowered.

Palpation of the tendon outside the groove, or of the empty groove, is pathognomonic, although these signs cannot be elicited in many cases because of the overlying structures. A change in direction may be more easily detected. If the onset has been gradual or if the tendon has slipped forward slightly, the symptoms and signs are not very striking. There may be a vague soreness in and about the groove, which is increased by movements of external rotation and overhead extension.

Diagnosis.—A diagnosis is not always made easily, especially if one does not bear this entity in mind during the examination of a shoulder. The symptoms may not be very pronounced at first and many of the objective signs may be obscured by the tenosynovitis and the generalized soreness which result from the production of such a lesion. The history is very valuable. In any disability of the shoulder, brought about by a sudden movement or by movements of external rotation and overhead extension, continued over a long period of time, the possibility of the production of a dislocation of the tendon of the long head of the biceps should always be considered.

In case of a dislocation, if the onset is acute, there is marked weakness of the arm and pain, more marked on movements of external rotation and overhead extension.

On inspection, if the subject is thin and has a well-developed musculature, one may detect the changed direction of the tendon of the long head of the biceps which, with arms raised horizontally, appears to run anteriorly and more mesial than normal.

The apparent elongation of the tendon with lowering of the belly may be present but difficult to recognize because of the reflex spasm of the muscle, especially if the injury is recent or the dislocation not very severe. Palpation will confirm what inspection has revealed and often is the only means of arriving at a diagnosis.

Diagnostic Test.—We have found the following test very useful in verifying the diagnosis of dislocation of the tendon. If there is a recurrent dislocation of the tendon (Cases II and IV), one can at times reproduce the dislocation by having the patient bring his extended arms to overhead extension and marked external rotation holding, if possible, an equal weight in each hand, such as five-pound dumbbells (Fig. 6). The observer places himself either behind or in front of the patient and puts his fingers on the long head of the biceps. The patient is then instructed to lower his outstretched arms to the side in the coronal plane. When the arms reach an angle of from 110 to 90 degrees, a definite snap may be audible in the top of the injured shoulder and a sharp pain is elicited both in the shoulder and in the region of the

bicipital groove. This snap is also felt by the fingers held over the belly of the biceps and the tendon of the long head. It gives the impression of a taut violin string that snaps as it slips into a groove of the bridge. Occasionally the vibrations produced by the snap may be visible in the long head of the biceps. This snap is not produced if the arm is lowered in internal rotation, or if the belly of the biceps, or the tendon of the long head is held and pushed firmly posteriorly, even though the arm is in external rotation. Since developing this test, I have found it present in my last three cases.

A diagnosis of a dislocated tendon can be made if one considers the mechanism of production of the injury and is careful in accounting for the various signs and symptoms. If the dislocation is not complete and recurring (Case III), the snap may not be detected so plainly. Then one has to rely upon the patient's subjective symptoms which are more severe when the arm is in external rotation and less so when it is in internal rotation or when the



FIG. 6.—(Case II.) Diagnostic test. See text for details.

tendon is pulled outward and posteriorly so that it does not reflect itself on the anterior structures of the groove and on the lesser tuberosity. In Case III, we verified this point, checking also with the other signs of Hueter⁴⁰ and Yergason⁷¹ which are both definitely positive as long as the tendon, brought into contraction, is not held back and outward. If one exerts outward pressure on the belly or, better still, on the tendon as high as possible under the anterior border of the deltoid muscle, these signs, even though they do not become entirely negative, elicit less pain.

Whether the tendon dislocates or ruptures and takes up a new and necessarily lower attachment in or along the edge of the intertubercular sulcus, the belly or muscle loses some of its tone and undergoes more or less atrophy. This explains why, at operation, although the tendon is of normal size and consistency, the muscle is flabby and can be lifted up much more freely than the short head (Case I).

Differential Diagnosis.—In the differential diagnosis of dislocation of the tendon of the long head of the biceps one must remember that the subjective and objective symptoms are often not very clear. A painstaking examination and repeated observations are frequently necessary before a definite diagnosis is reached. This results from the fact that in the shoulder, and espe-

cially in the region of the bicipital groove, there are so many important structures, one overlapping the other and most of them very deeply situated.

Subdeltoid Bursitis.—As mentioned before,²⁹ in subdeltoid bursitis the pain and tenderness are localized in the region of the bursa and are increased by passive or active external rotation and abduction. None of the important symptoms of the bicipital syndrome are present.

Soto-Hall and Haldeman⁶⁶ emphasized the fact that the injection of novocain into the subdeltoid bursa is a very valuable means of differentiating an injury of the subdeltoid bursa from a tear of the supraspinatus tendon. I have found this to be a useful procedure.

Rupture of the Supraspinatus Tendon.—A lesion of this tendon should not be mistaken for a dislocation of the long head of the biceps. For a complete study of the supraspinatus tendon the reader is referred to Codman's excellent book.¹⁵

The dislocation may be anterior or posterior, but only the former is identified with the bicipital syndrome. The principal signs, of course, are the changed direction of the tendon, palpation of the empty groove or of the tendon outside of it if possible, and the tendon having a more anterior and mesial position. If the dislocation is complete, it may be confused with a rupture of the high type or with an elongation. A detailed history of the onset of the disability and of its mechanism may be helpful, as a luxation has always a forced abduction and external rotation as one of its main factors. In a case of dislocation, the tendon is still under tension, more so than in a rupture, and the muscle therefore is not so flabby. Impairment of function is greater in a dislocation, especially on movements of rotation and slight abduction, and also on those of flexion of the forearm. In a rupture, the movements of flexion are much more impaired than those of abduction and rotation. A rupture of the low type has signs and symptoms distinctly different and it eliminates immediately the diagnosis of dislocation, elongation, or a high rupture of the tendon.²⁹ If the dislocation is not complete, the diagnosis may be made by the change in the symptoms, that is the lessening of objective and subjective findings when the tendon is held firmly and pushed backward and externally, either by means of the belly or, better, by direct pressure on the tendon under the anterior margin of the deltoid. The high type of rupture may be confused with the true elongation of the tendon, but the latter is rather a rare condition. An apparent elongation is caused, therefore, by a dislocation or a high type of rupture. Thus, by elimination, one can attain a fairly accurate differential diagnosis.^{6, 29}

Elongation of the Tendon.—A considerable number of cases of elongation of the long head of the biceps tendon have been reported; most of them, however, were undoubtedly apparent rather than real. A true type of elongation is, according to Bera,⁶ the result of numerous ruptures of single fibers in the thickness of the tendon. An apparent elongation is the result of a dislocated tendon or of a rupture of the high type with subsequent lower attachments, or of the low type with the formation of scar tissue between the two

ends of the tendon and subsequent atrophy of the muscular belly. The true type of elongation may become a complete rupture when the tendon, after repeated ruptures of the fibers, gives way completely. Cases of true elongation are very rare, but such an elongation of the upper tendon was reported by Bera,⁶ and Holcomb³⁸ had a case, in which operation revealed that the lower tendon "had slipped down through the muscle very much as the center of a roller bandage is pulled out of the bandage."

Treatment.—If the tendon is dislocated and the patient is seen early, an attempt should be made to reduce the dislocation by the following procedure, which I have used on several occasions. The extremity, with the elbow bent and the forearm supinated in order to relax the tendon, is abducted passively and gently in the coronal plane to 90 degrees or more and simultaneously rotated internally. Sometimes it may be necessary to grasp the belly of the biceps as high as possible, near the deltoid muscle, pull it backward and hold it as the arm is lowered in the same plane, to help the replacement of the tendon and also to prevent a possible, although rare, immediate redislocation. Anesthesia may be required to overcome the reflex spasm of the structures in the shoulder.

If the patient is seen some time after the dislocation occurred the treatment really depends on the subjective symptoms and especially on the disturbances of function. If they are not very severe, it may not be necessary to intervene surgically, as the tendon and the structures around the intertubercular sulcus will have adapted themselves to the new condition. If the patient is engaged in heavy work which requires constant use of his biceps, the best procedure is to operate early as there is every reason to believe that, if he is having trouble a fairly long time after the accident, his condition will not improve, but will probably get worse.

The surgical repair varies according to the operative findings. If the structures around the groove are such that their repair will give assurance of a good result, this should be done, and, if necessary, the groove should be deepened. An easier procedure, and one probably more satisfactory, is to repair the tear in the structures around the groove, after severing the tendon of the long head as high in the joint as possible, and then to suture this tendon to the coracoid process and to the tendon of the short head (Fig. 7) as described previously.^{27, 28} This has invariably given a satisfactory result.

Prognosis.—The outlook depends both on the severity of the injury and on whether there are other concurrent lesions of the shoulder girdle. In the latter case the lesion of the tendon is of secondary importance, though when present it should be recognized early and treated as soon as the other injuries have received attention. In case the dislocation is isolated, spontaneous reduction may occur under a sudden movement which returns the tendon to its normal position. In this case soreness may persist for several days. If the reduction is not accomplished soon, newly formed adhesions may fix the tendon to the humerus or the tendon may be reflected in a capsular sling and work through this newly acquired position, as shown by Meyer.^{47, 48, 49} In

such a case there may be discomfort and functional disturbance of varying extent, according to the degree of relaxation of the biceps and to the subsequent shortening of the muscle if any, especially to the pulling and tugging on the stretched capsule where it forms the capsular sling.

An acute dislocation requires immediate reduction because of the intensity of symptoms and the duration of disability, if reduction is not accomplished. A dislocation which has developed gradually may not produce many symptoms nor be very disabling.

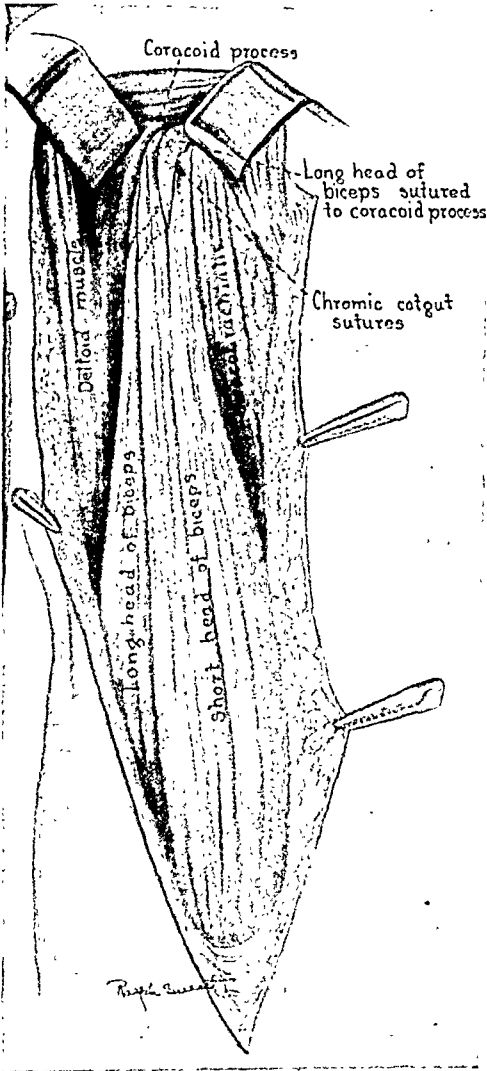


FIG. 7.—The tendon of the long head of the biceps inserted through the tendon of the short head to which it is sutured, as well as to the coracoid process.

Medicolegal Aspect.—The medico-legal aspect depends, of course, on many factors, especially on the amount of disability which may arise as a result of a dislocation of the tendon and on the time of onset of the disability. There is no question as to industrial liability in the acute type. Its onset and mode of production are very clear. There is question, however, in a luxation which has been produced gradually, as in the case of workers who use their arms in external rotation and abduction, such as painters, carpenters, decorators, miners, fruit pickers, etc. Usually many of their symptoms are attributed to arthritis or sprains for a while until they, with a slight effort, stretch the capsule a little more and therefore cause immediate disability. Each individual case, therefore, should be studied carefully, especially if the onset is not sudden. In all fairness to the employee one must not forget that there is, at times, an occupational factor in these cases and that, since the soft tissues in various shoulders give way differently and to a varying degree, the symptoms change from case to case and from time to time in the same patient according to the amount of reaction

produced by the injury and often by an examination. In fact, symptoms may appear or disappear on two successive examinations. It is very important and highly essential to the contending parties that the surgeon, who accepts the care of these cases or whose opinion is sought, obtain a complete history of the accident, a clear idea of the mechanism of production of the injury and an understanding of the underlying causes in order that he may be able to render a just opinion.

APPENDIX

Literature.—Hippocrates³⁷ was the first to give any information about musculotendinous displacement in luxations. In 1724 William Cowper¹⁷ reported a dislocation in which both tendons of the biceps were rigid, interfering with extension of the elbow and in which, after manipulation, function was restored. Pouteau,⁵⁷ in 1760, doubted that tendons could be displaced. Bromfield,¹⁰ in 1773, wrote on the technic of reduction,* Knox,⁴² in 1827, was the first to notice a morbid condition of this tendon; Stanley,⁶⁷ in 1828, reported one case, found at autopsy, in which the tendon was dislocated from its groove and resting over the greater tuberosity. Monteggia,⁵⁰ in 1829, reported a recurring subluxation which could be reduced by placing the outstretched hand and arm over the shoulder of another person; John Gregory Smith,⁶³ in 1835, found at autopsy among other lesions of the biceps two instances of dislocated tendons in the two shoulder joints of the same subject; Adams,¹ in 1835, considered that chronic arthritis was the underlying factor of dislocation as evidenced in the case of J. G. Smith. He also believed that, in Soden's case, the dislocation was the result of arthritis rather than of trauma. John Soden,⁶⁵ in 1841, reported two cases one of which has been the subject of much discussion; Partridge,⁵⁴ in 1841, discussing Soden's case, considered it traumatic; Cooper,¹⁶ in 1842, wrote a treatise on the subject; Hancock,³⁶ in 1844, gave a good clinical description of this subject; Smee,⁶² in 1848, also wrote on it; Callaway,¹² in 1849, wrote a dissertation on the subject and cited a specimen (No. 55) kept in St. Bartholomew's Hospital as an example of dislocation. He discussed the difficulty of a differential diagnosis between rupture and dislocation; Parrish,⁵³ also in 1849, reported one case; Erichsen,²⁰ in 1850, wrote on the subject; Postgate⁵⁶ reported one case in 1851; Fergusson,²² in 1853, said he had no doubt that the bicipital tendon could be displaced in dislocations as he had seen this more than once in the dissecting room; Robert W. Smith,⁶⁴ in 1853, reviewed several cases recorded in the literature as instances of partial luxation of the humerus upward with dislocation of the bicipital tendon (those of Gregory Smith, Fergusson, Smee and Hilton) and concluded that they were not of traumatic origin but the result of arthritis; Schiff⁵⁹ wrote on the subject in 1855; Hamilton³⁴ reported one case and Malgaigne⁴⁴ discussed the subject and especially Soden's case. He denied a traumatic luxation of the tendon unless it occurred as a complication of fracture or luxation of the shoulder; Sebergondi,⁶⁰ in 1856, reported one case; Mercer,⁴⁶ in 1859, reported one case of dislocation of the shoulder with luxation of the tendon; Hueter,⁴⁰ in 1864, gave a very clear explanation of some of the signs and symptoms in lesions of this tendon; Jarjavay,⁴¹ in 1867, discussing several cases, thought that the signs reported were not the result of a dislocation of the tendon, but in the light of his studies, were caused by a subacromial bursitis. He further stated that a simple luxation of the tendon had never been demonstrated and, in his opinion, did not exist. Fleury,²⁴ in 1868, reported a case traumatic in origin, while Von Pitha⁵⁵ agreed with Jarjavay⁴¹ and questioned the diagnosis in several of the cases reported which was "founded on symptoms referred to the neighborhood of the bicipital groove and on the associated disturbance of function." He also said that "no one had ever felt a luxated tendon on the greater tuberosity or been able to replace it." Ashurst,⁵ in 1871, wrote that Canton believed the

* "... the cubit being bent the muscle is relaxed and while an assistant holding the lower extremity of the os brachii, moves the head thereof, sometime inward, sometime outward in the acetabulum scapulae: the operator with his fingers will easily replace it and the patient presently becomes perfectly easy."

dislocation to result from the existence of chronic rheumatic arthritis; Hood,³⁹ in 1871, wrote, "displacement of a tendon is certainly of more frequent occurrence than is usually supposed"; Adams,² in 1873, said that the luxation of the tendon was the result of arthritis and not of trauma; Green,³⁰ in 1877, reported a case, the result of a fall, which was reduced by a second fall; Agnew,³ in 1878, wrote that the only unequivocal case he had seen was that of White;⁷⁰ Callender¹³ mentioned one of recurring dislocation in which the tendon could not be retained in place because of fibrous tissue filling the groove and cited specimens in the London museums showing displacement of the bicipital tendon; Gerster²⁶ wrote that no luxation had been found, in the living subject, in its uncomplicated form and doubted its existence as such; in his opinion, when concomitant to injuries, it was a secondary pathologic phenomenon. Hamilton,³⁴ in 1880, cited one case of luxation; Andrews⁴ a year later doubted that this tendon could dislocate, while Nancrede⁵¹ was of the opinion that the so called luxation of the long head of the biceps was the result of chronic subdeltoid bursitis; Gross,³¹ in 1882, conceded that the obscure nature of the lesion allowed it to be overlooked or mistaken for fracture, sprain or dislocation of the shoulder; Madyl,⁴³ also in 1882, wrote on the subject in general; Treves,⁶⁸ in 1883, recognized a traumatic dislocation of this tendon; von Volkmann⁶⁹ in the same year said that uncomplicated luxation of the tendon had not been found at autopsy. However, he mentioned a case recorded by Cloquet in which the patient could dislocate his biceps tendon at will. J. William White,⁷⁰ in 1884, reviewed the literature and discussed a case in which he believed there was a traumatic luxation of the tendon. Eastland,¹⁹ in 1886, reported one case; Senf,⁶¹ in 1892, wrote on the subject; Guernonprez and Ahmed Michel,³² in 1896, reported one case concurrent with a dislocation of the shoulder; Marsh,⁴⁵ in 1896, Parkhill⁵² in the following year and Robinson,⁵⁸ in 1902, wrote on the subject, each reporting one case; four years later Berne⁷ reported two cases; Bossuet,⁹ in 1907, reported two; Fievez,²³ in 1910, reported a case of elongation, and in the same year, Bera⁶ wrote a classical thesis on the subject. Borchers, in 1914, writing on lesions of this tendon, mentioned that it could become displaced mechanically by osteophytic outgrowths of arthritic origin which fill the groove. Gurlt,³³ in 1927, found one case of tendon dislodged by the filling of the groove.

CASE REPORTS

Case I.—A. N., male, aged 49 years, was seen first on September 22, 1925. He had hurt his right shoulder the day before, when he was standing in a crouched position, pulling a heavy steel bar which he had just driven into a board with a sledge hammer. He gave a quick pull and instantly heard a snap in the anterior portion of the top of his right shoulder followed immediately by a smarting sensation rather than severe pain. He continued working, but was unable to pull, as such effort produced pain in his shoulder. The next morning he had difficulty in raising his arm because of soreness in the upper part of his arm and his shoulder.

Examination.—September 23, 1925, no ecchymosis or tumefaction was visible. By abducting and externally rotating the arm a definite snap was felt and heard in the shoulder where the long head of the biceps emerges from the joint. This phenomenon was attributed to a recurring dislocation of the tendon of the long head of the biceps which, on rotation of the humeral head, came out of its groove and over the lesser tuberosity and then snapped back into the groove.

After a few weeks' treatment, consisting of rest and heat, the patient's symptoms subsided and he resumed his usual work, but he soon returned again complaining that his arm had grown weak and that the following movements hurt him: (1) lifting with the

DISLOCATION OF BICEPS BRACHII

arm extended; (2) putting the arm back to get into his right hip pocket; (3) rotating the arm with it extended in front; (4) pulling the arm back from forward extension. He located the pain exactly in the middle of the anterior portion of the shoulder, where the tendon of the long head of the biceps emerges from the joint.

On December 26, 1935, with arms abducted and extended, the normal convexity of the long head of the biceps was absent entirely and was seen to be flattened. The bone could be palpated between the deltoid and the belly of the biceps. On flexing the forearm only the belly of the short head was seen to contract and there were 6 cm. between the muscular belly and deltoid fold, as compared to $1\frac{1}{4}$ cm. on the uninjured side (Fig. 8).

Diagnosis.—Dislocation of the long head of the right biceps.

Operation.—January 2, 1926, under general anesthesia, a linear incision was made over the long head of the biceps muscle. The muscular portion of the long head was smaller than normal, but there was no tear in it. The tendinous portion was normal. However, the long head was elongated and could be lifted like an overstretched rubber band, as compared with the short head which had its normal contractile power. In the light of these findings it seemed best to shorten the tendon by plication, thus reducing its length about 1.5 cm. The arm was then immobilized in acute flexion in a Velpeau bandage to relieve all strain and to restore its contractility.

Result.—The patient regained complete use of his arm, and seven weeks after the operation returned to his usual work as a carpenter (Fig. 9). The muscle regained its normal size, and he was discharged as cured. Nine years later on examination I found that his arm was still normal in every respect. Even though the patient obtained such a perfect result, in a similar case I believe I should sever the tendon as high up as possible and suture it to the coracoid process and to the tendon of the short head.

Case II.—A. D., male, aged 40 years, was seen first on October 8, 1931, complaining of pain and weakness in the right shoulder and arm. On the previous day while trying to loosen some poles with a crowbar, and pulling, he suddenly felt two consecutive sharp snaps in his right shoulder and in the middle internal aspect of the right arm, as well as a dull pain in his right shoulder. He rested an hour and exercised his arm, with the hope that the pain would subside, following which he went back to his regular work of washing carpets and worked the remainder of the day, although his right shoulder pained. The pain increased gradually until the next morning he could hardly raise his elbow.

Examination.—He localized the pain by putting his finger along the tendon of the long head of the biceps which was tender to pressure, especially over the bicipital groove. Yergason's sign²⁷ was positive. After many painstaking examinations the diagnostic test spoken of in this paper was worked out and perfected. Roentgenologic examination was negative.

Diagnosis.—Dislocation of the tendon of the long head of the right biceps.

Treatment.—Rest with the shoulder in an abduction splint and diathermy afforded him some relief.

Result.—Operation was advised, but he preferred instead a settlement from the insurance company. He was examined recently and while the general soreness about his shoulder has improved, he still has pain when he raises his arm above his head and rotates it externally. The snap, as described in the test outlined in this paper, is still present.

Case III.—J. T., male, aged 43 years, was first seen on May 3, 1933, complaining of weakness, stiffness and a continuous dull aching in his right shoulder, more severe on movement, which prevented his raising his right arm above the level of the shoulder. On January 11, 1933, while he was pushing a hand truck, weighing about 538 pounds, over an incline, his foot slipped on the wet sidewalk and he fell forward. He struck his right shoulder on the handle of the truck. For the rest of the day (two hours) he did light work. In spite of the use of hot compresses, the aching in his shoulder was so severe that he could not sleep. Two days after the injury he consulted a physician, who first had roentgenograms taken of his shoulder and then strapped his arm to the

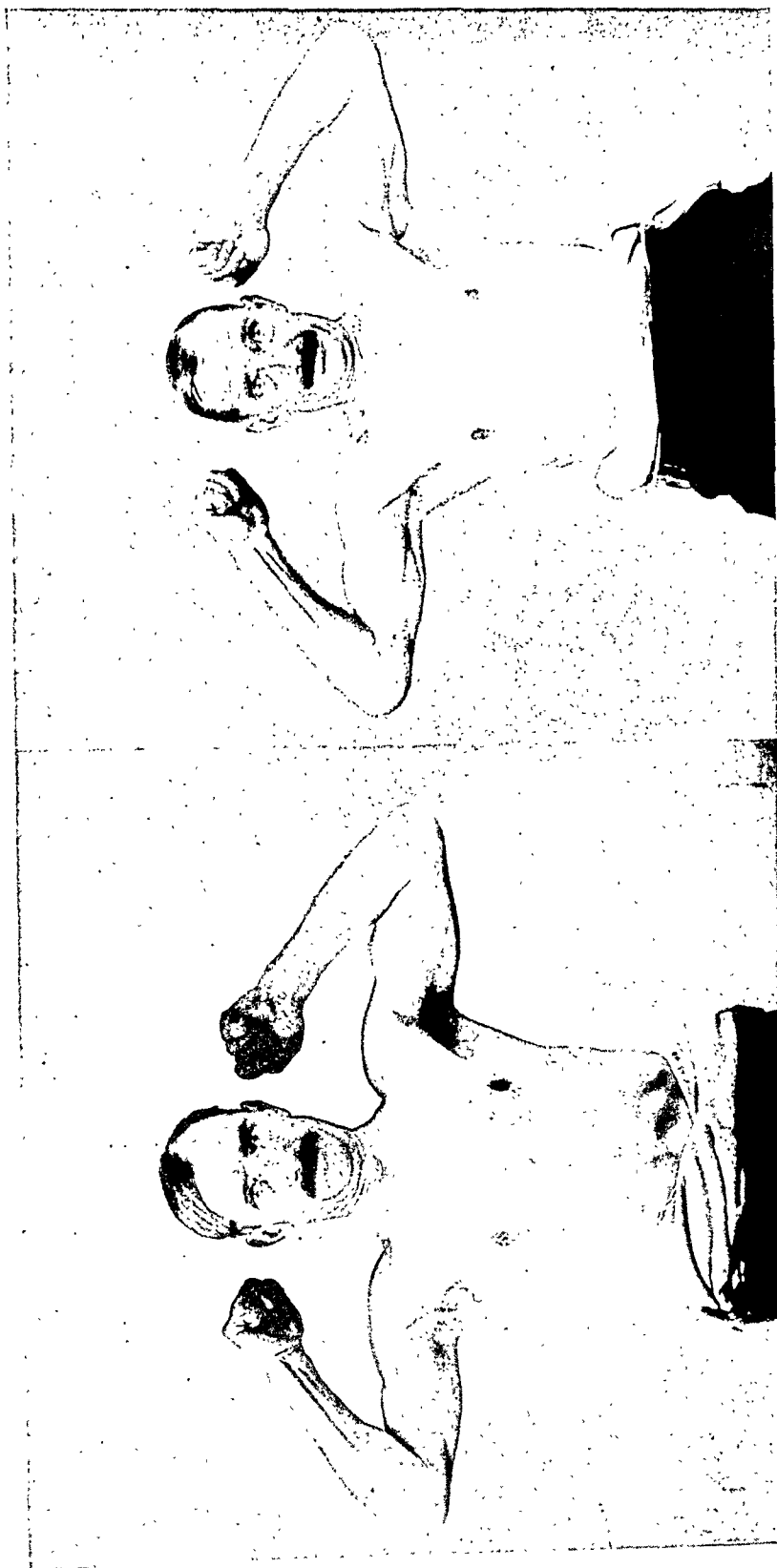


FIG. 8.—Case I. (Before operation.) Dislocation and elongation of the tendon of the long head of the right biceps. Note diminution in size, as well as the widening of space between the biceps and deltoid muscles.

FIG. 9.—Case I. (Few weeks after operation.) Note how the muscle of the long head of the right biceps has increased in size, and how the contour of the arm is more nearly normal.

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side of his chest. Since the strapping did not relieve the pain, it was removed in two days and he was given radiant heat and diathermy for a few weeks, without relief.

Examination.—General physical examination was essentially negative except for moderate pyorrhea, chronic tonsillitis and very mild chronic sinusitis and chronic prostatitis.

Right arm and shoulder.—There was a definite flattening of the right deltoid region, especially when the elbow was at the level of the shoulder. A marked depression, 10x11 cm., was evident in the substance of the deltoid muscle just below the acromion process. This area, corresponding to the level of the subdeltoid bursa, was tender to pressure, and it was at this point that he felt most of the pain on movement. There was a slight atrophy of the muscles of the scapulohumeral region. Movements were limited about 20 degrees. It was difficult to ascertain the range of motion of his right shoulder because of the pain whenever he moved the arm. On palpation he complained of tenderness in the region of the subdeltoid bursa and at the level of the intertubercular sulcus, and there was a point of tenderness which rotated with the rotation of the arm and which did not disappear when the arm was abducted. There was no definite change in the scapulohumeral rhythm nor a definite jog on abducting or adducting the arm after it had been extended overhead. At that time, examination of the long head of the biceps and of its tendon was clinically negative.

Roentgenologic examination of the right shoulder.—Outward rotation showed a small area of calcification above the greater tuberosity of the humerus, probably the result of an old hematoma.

Impression.—(1) Severe contusion of right shoulder with (2) probable partial tear of the tendon of the right supraspinatus muscle and of muscular fibers of the right deltoid muscle; (3) subdeltoid bursitis; (4) chronic tonsillitis, slight pyorrhea, and low grade sinusitis.

Treatment.—He was treated conservatively with rest of the shoulder in an abduction splint, physiotherapy, and injections of iron cacodylate intravenously which, on several occasions, I have found to be very efficacious in relieving the pain of subdeltoid bursitis.

Discussion.—The patient was kept under observation for many months, during which time he was treated conservatively and several foci of infection were given attention. The condition and the range of motion of his shoulder gradually improved. When most of the pain had subsided, his clinical picture gradually became clearer and, after painstaking and continual observation of his symptoms and signs, it became evident that he had a *partial dislocation of the long head of the biceps*. On November 6, 1933, Hueter's sign and Yergason's sign²⁷ were positive. The diagnostic test mentioned previously did not elicit a very definite snap, but there was more severe pain when all these three signs were tested without holding back the muscle belly or the tendon of the biceps, pushing it outward and posteriorly, or when the arm was lowered in internal rotation. This maneuver evidently held back into the groove the tendon of the long head so it reflected itself over the slope of the lesser tuberosity and not over the sling formed by the tearing of the capsule which occurred at the time of his injury when he had abducted his right arm violently and brought it in overhead extension and external rotation. He had, therefore, put indirectly a great strain on the attachment of the articular capsule in the region proximal to the lesser tuberosity which forms the roof of the osteofibrous tunnel of the bicipital groove.

Progress.—After a year and a half of conservative treatment, his range of motion was almost normal and the weakness and pain in his arm were greatly relieved. He was discharged as being able to resume work.

Case IV.—R. G. H., male, aged 50 years, dentist, was seen first on December 9, 1933, complaining of neuritis in his left shoulder and arm. About seven years before, he began to have a dull ache in his left shoulder which radiated down his arm and which he attributed to muscular strain. This condition had become worse slowly and progressively until, at the time when I first saw him, he was even disturbed at night. In fact, he

had to sleep on his back with his left arm abducted to 90 degrees, the elbow flexed at a right angle and the hand at the level of the head. Recently he had not been able to bring his arm above a horizontal plane unless he twisted his forearm, first supinating and abducting it, then pronating it while he gradually lifted it with the other hand. The pain ceased after he abducted his arm to about 80 degrees. He also had pain radiating down the biceps when he leaned back against a chair.

Examination.—A creaking sound could be heard in both shoulders on the abduction of both arms. There was pain on pressure at the lower end of the left bicipital groove. Hueter's and Yergason's signs were negative. He could abduct his left arm to 75 or 80 degrees without pain, then he halted because pain was elicited in the shoulder. To obtain overhead extension, he lifted his left arm in medial rotation with elbow slightly flexed until he reached about 45 degrees abduction. Then he had to rotate the arm externally, after which with a jerk and twinge of pain he was able to accomplish overhead extension.

Abduction and elevation of the left arm were not so painful when the biceps muscle was held and pushed outward, as if to hold the tendon back in the groove.

Progress.—Operation was declined. His condition remained almost stationary and about a year after he was seen last, he had to give up his work on account of pain in the shoulder.

Case V.—V. M., male, aged 52 years, on March 24, 1933, fell, striking on his right shoulder. He tried to check his fall with hand and wrist against the ground by strongly rotating the right arm externally. The instant he struck the ground he felt a snapping sensation "like a string breaking." Inasmuch as he felt as if the shoulder were out of joint, other workmen pulled downward on the arm with counter pressure in the axilla, and the shoulder seemed to snap back into place. He felt better after this but on account of soreness in his shoulder and arm, was unable to work. He saw a physician and was advised to keep his arm at his side. He first began to use his arm in about two weeks. Finally he felt well enough to work four days during the first week of June, but a return of pain stopped him. He worked three days during the last week of June. He suffered no pain with his arm across his chest, but attempts to use the arm caused pain at the top of the shoulder; a fairly regular snapping was heard and felt deep in the upper front part of the joint and over the front of the humerus at or just below the insertion of the pectoralis major muscle. His condition did not improve. The patient gave a history of never having had arthritis, lumbago, neuritis or sciatica.

Examination.—July 22, 1933, the right shoulder snapped audibly when abducted and rotated. This snapping, I thought, was caused by the tendon of the long head of the biceps which seemed to be displaced forward, lying just in front of the tip of the coracoid, and which snapped back and forth at the level of the tip of the coracoid on abduction and particularly rotary movements in from 60 to 80 degrees abduction. He felt pain over the tip of the coracoid when the snapping occurred, and this area was distinctly tender. There was a slight tenderness also over the region of the subdeltoid bursa. There was very little atrophy. Normal range of movement was present.

Roentgenologic Examination.—Roentgenograms (stereoscopic, internally rotated and single, externally rotated) taken July 22, 1933, showed a small calcified mass in the region of the subdeltoid bursa. There was also a curved narrow line of increasing density in the region of the bicipital groove which was interpreted as calcification where the periosteum had been torn when the tendon of the long head of the biceps was forced from its groove. On the inferior surface of the clavicle a well-developed bony prominence appeared where the coracoclavicular ligaments attach, but the normal relations of clavicle and scapula excluded injury as a cause, and the pattern of the bone seemed normal and did not suggest an arthritic etiology.

Impression.—A forced active movement of external rotation and supination against resistance has caused the tendon of the long head of the biceps to tear loose from its groove. It now lies just anterior to the coracoid process and certain movements cause it

to snap back and forth at the level of the tip of the coracoid, causing pain and chronic irritation.

Operation.—August 5, 1933, a six-inch incision was made along the anterior margin of the deltoid muscle. The deltoid was separated from the pectoralis major by sharp dissection and retracted laterally and upward. The tendon of the long head of the biceps was felt lying medial to its normal location in the bicipital groove. The transverse humeral ligament was found detached from the lesser tuberosity of the humerus for a distance of 1 to 1½ inches. It was cut to expose the bicipital groove. The biceps tendon lay outside the groove at this point, having slipped across the denuded lesser tuberosity. The point of the lesser tuberosity was sharp and prominent, and movements of the arm caused the tendon to snap over it. This was evidently the chief cause of the painful snapping at examination. The nature and extent of the damage made repair of the transverse humeral ligament impossible. Repair by fascia lata would have required bone work at the subscapularis insertion, which would have been painful for some time, with slow convalescence.

The cut biceps tendon was freed of areolar tissue and split, each half being looped through the bone tunnel and sutured to the outer half in the groove. The transverse humeral ligament and periosteum were closed over and sutured to the tendon in the bicipital groove, with interrupted No. 0 chromic catgut. The deltoid was replaced and lightly sutured with No. 00 plain catgut. The skin was closed with interrupted black silk without drainage. A starch bandage and yuca board were applied with the elbow flexed and the arm held in the Velpeau position. Convalescence was uneventful. He returned to light work much improved on November 28, 1933, and since has resumed his regular heavy work.

*Case VI.**—J. T., male, aged 49 years. On December 22, 1933, a piece of equipment, weighing 200 or 300 pounds, toppled two or three feet and struck the front of his left shoulder, his arm being forced into external rotation in a position of 60 degrees abduction. The weight pinned him against the flat surface on the wall behind. As his shoulder was painful he did little work for the rest of the day. A swelling the size of a walnut appeared on the front of the shoulder, but gradually subsided. He complained of pain over the front of the shoulder and a cracking sensation on raising the arm from the side. Any use of the arm caused soreness which lasted for some time. At first he had pain in the shoulder at night, but it became less. He could do straight lifting with arms dependent without pain, so long as he did not abduct. He had no previous injuries, arthritis, lumbago or neuritis, and his general health was good.

Examination.—Examination of the left shoulder on January 23, 1934, revealed a clicking and grating on motion. The biceps tendon clicked. The biceps (long head) did not contract firmly unless he made a special effort. There was some crepitation and pain in the shoulder on abduction of the arm. Range was not restricted. There was tenderness and a click on rotation in the region of the bicipital groove, especially with the biceps taut. Roentgenologic examination was negative.

Impression.—The tendon of the long head of the biceps slips out of the groove. Thickened soft parts crepitate and pinch slightly in passing under the acromion.

Operation.—January 26, 1934, the tendon of the long head of the biceps was exposed. It had torn the transverse humeral ligament and lay about one inch anteriorly to its normal position. The groove which it normally occupied was so filled with lacerated soft tissue and granulations that the tendon could not be replaced in its normal position. The tendon itself was frayed along one margin.

The shoulder joint was opened and the tendon cut free from its attachment to the scapula. The tendon was denuded of areolar tissue and split longitudinally. The bicipital groove was denuded of soft parts and a small tunnel was made through the bone. Through this tunnel one-half of the split tendon was looped, and brought back and sutured to the

* I am indebted to Dr. Edward C. Bull for the report of both Cases V and VI.

other half. The reflexed periosteum and soft parts were sutured over the transplanted tendon. The incision in the shoulder joint was sutured and the deltoid muscle was brought back to its normal position and likewise sutured.

Progress.—His shoulder improved very definitely, and his arm was freer and stronger, but as he continued to have pain on abduction and external rotation, it was decided to do an exploratory operation.

Operation.—February 2, 1935, it was found that the greater tuberosity was striking the acromion as it moved beneath this bone in the act of abduction.

Progress.—Since the second operation he has been even more relieved and is still improving.

I wish to express my appreciation to my associate, Dr. Piero Albi, for his splendid assistance in the preparation of this paper, for reviewing much of the foreign literature and for compiling the complete bibliography.

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LIPOMA OF THE EXTREMITIES

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DURING the course of a general study on the clinical characteristics of soft tissue tumors of the extremities, it has become increasingly apparent that the benign lipoma plays an unappreciated though extremely important rôle. Lipoma is the diagnosis in over 50 per cent of these neoplasms, and its very frequency, disarming to unguarded observation, makes it the most common diagnostic error to be found in any series of such cases. The true importance of this error lies in the fact that about one-third of the soft tissue tumors occurring on the extremities are malignant or potentially so, and a false diagnosis of lipoma too often leads to inadequate therapy. It is common knowledge that surgical trauma, improperly or incompletely administered, especially to a tumor of the sarcoma group, is one of the activating forces of primarily low grade malignancy. Hence the casual enucleation of a supposedly benign lipoma in a patient subsequently lost to the clinic before the pathologist's report becomes available, or reassured without histologic confirmation of the diagnosis, may cause an avoidable loss of life or limb.

It has been shown elsewhere that the common soft tissue tumors of the extremities do not appear at random, but present clinical characteristics which suggest, if not determine, their diagnosis. We know of no such study concerning the lipomata. One hundred sixty-two lipomata, representing 54 per cent of 300 soft tissue tumors of the extremities form the material upon which this report is based. It portrays the clinical history of these neoplasms, their diagnostic criteria, and indicates the proper considerations for therapy.

Surgical Pathology.—Lipomata are tumors composed of neoplastic fat cells growing in a more or less dense fibrous stroma. The density of the fibrous stroma varies with the location of the tumor, and, in a true lipoma, is of no pathologic significance. However, this variation in the density of the stroma has led to unnecessary and confusing subclassification such as fibrolipoma or lipofibroma. These terms should be used only in those rare cases where actually neoplastic fibrous tissue is present along with lipomatous growth. Otherwise only the term lipoma is justified. Grossly these tumors appear as a mass of fat which may or may not be encapsulated. A lattice work of fibrous strands can be seen within the mass. The fatty tissue appears lobulated, and on careful inspection a vascular tree can be seen with minute vessels feeding each lobule. Histologically when stained with hematoxylin and eosin, the typical "engagement ring" cell is observed, with a single nucleus placed peripherally in a transparent protoplasm surrounded by a well defined

cell wall. The fibrous strands of the stroma appear as simple connective tissue within which are found the minute blood vessels and nerve filaments.

Etiology.—Trauma while occasionally mentioned in the histories of these cases as preceding the onset of tumor cannot be seriously considered as an etiologic factor. The favorite sites of election, and the frequent occurrence of these tumors without any appreciable trauma, eliminate its probability if not its possibility.

Location.—About one-half of these tumors occurred in the upper extremities, and one-half in the lower. In the upper extremity, 55 per cent occurred in the region of the deltoid muscle, and 21 per cent at the axilla. Together, 76 per cent of lipomata of the upper extremities were found about the shoulder joint. The remainder appeared equally divided along the extremity, but were usually found on the flexor surfaces. In the lower extremities, the distribution was homologous. Eighty-three per cent appeared either on the buttocks or on the upper half of the thigh. (This is in distinct contrast to fibrosarcomata, which occur predominantly at the lower half of the thigh.) The predilection of lipomata for areas of greatest fatty tissue deposit is obvious.

In 20 of our cases (12 per cent), the tumors were multiple, ranging from two to six in number. Although there was a wide distribution of the multiple tumors, frequently involving not only the extremities, but also the trunk, in many instances the tumors were found concentrated on the forearm of a single limb. The suggestion has been made that multiple lipomata occurring on a single limb may be related to a nerve distribution, therefore they may have a neurogenic relationship. In our group the distribution in the forearm cases was anatomically so diverse that no single nerve tract could be held responsible. Cases of generalized lipomatosis were not included in this study, since they represented concepts extraneous to the present problem.

Lipomata of the extremities are almost always found in the subcutaneous tissues. However, they may appear in the muscles, in the intermuscular spaces, or even in relation to bone. Kuttner and Landois, in 1913, gathered 27 cases from the literature in which lipomata were situated within muscle tissue. Mullen, in 1932, noted that intramuscular, or, as he termed them, "intrafascicular" lipomata were most commonly found within the triceps cruralis and the biceps brachialis. None of our cases was intramuscular.

Behrend described a series of lipomata found within the intermuscular spaces. Three such (1.7 per cent) appeared in our list. Intra-articular lipomata, derived from the fat pads of the large joint, or the adipose tissue of the subsynovial layers, while not common, are by no means rare; especially within the knee joint. These have been described by many authors. They grow into the joint space, sometimes to a large size, and often resemble a localized synovial hypertrophy. However, on arthrotomy, the true lipoma is found to be a demarcated mass, frequently pedunculated, in the midst of normal synovia, while synovial hypertrophy, always secondary to synovitis,

is more diffuse, congested and is apt to show areas of mucoid degeneration on its surface.

Lipomata of bone are rare but do occur within the bone marrow. Ewing describes a case occurring within the marrow of the fibula of a young girl. In such cases there are said to be no signs or symptoms either clinically or roentgenologically. Their presence is usually disclosed as an incidental finding. However, another form of lipoma involving bone, equally as rare, is of greater consequence, since it closely simulates a bone tumor. This is the so called periosteal lipoma. Two such cases were described by Bartlett, and Geschichter and Copeland have described another. This lipoma becomes attached to periosteum, probably as part of its fibrous capsule. As it grows it presses against the cortex of the bone. Two reactions have been described. In one the bone appears to be bent by the pressure of the growing tumor, in the other, a depression is made on the cortex which in the roentgenogram gives the appearance of erosion and suggests osteogenic sarcoma. However, there is no periosteal reaction visible, no changes in skin overlying the tumor, and at operation, a flattened depression is seen without any invasion of bone tissue. The cortical line, though depressed, remains intact. One such case occurred in the present series, in which the lower end of the fibula in a young woman was involved.

Age of Onset.—Lipomata may appear at any age but are preponderantly tumors of middle life. Seventy-five per cent of the cases appeared between the ages of 20 and 50, equally divided among the three decades. In two of the cases the tumors were said to have been congenital, although no medical evidence proved the statement. At least they did appear in infancy.

Duration.—Figures concerning duration in these benign tumors are meaningless. They run from six months to 30 years. The duration of tumor depended upon many irrelevant factors, among which were cosmetic, fear of "cancerous change," inflammation in or about the tumor, local infection or ulceration, and in some cases the insistence of medical advice in patients appearing for other causes. Lipomata of the extremities have lasted a lifetime, remaining stationary after reaching a given size which may be that of a grape or a grapefruit.

Pain.—Lipomata are not *per se* painful tumors. However, it must be emphasized that this is not an important differential characteristic since pain is rarely an important presenting symptom in certain of the other common soft tissue tumors of the extremities. When pain is present in lipomata of the extremities it is due either to anatomic encroachment on neighboring tissues subject to painful stimuli, such as nerves, muscles or periosteum; or due to inflammation, usually traumatic, of the tumor itself. One case in this series was admitted because of persistent pain, with edematous swelling and cyanosis of an upper extremity. This was caused by an axillary lipoma obstructing the brachial vessels. Occasionally one finds a lipoma producing pain radiating along a nerve, suggesting the diagnosis of Schwannoma or neurofibrosarcoma. This symptom has been shown not to be pathognomonic of

Schwannoma, although of course strongly suggestive of it, since any tumor surrounding and pressing on a nerve may cause such pain.

Physical Characteristics.—These neoplasms are usually soft, but their consistency varies with the density of the fibrous tissue stroma described above. However, they are not as firm to touch as are the true fibrous tumors. Occasionally their softness may be extreme and suggest fluctuation. Lipomata of the extremities vary in size from that of a grape to a grapefruit. Rarely they attain even larger proportions. They are mobile within the subcutaneous tissues, but when attached to deeper structures they may be sessile, pedunculated, or diffuse. The last form is characteristic of intramuscular lipomata. They are never tender unless inflamed. Soft tissue sarcomata, on the other hand, are frequently tender. Subcutaneous lipomata usually appear well demarcated on palpation. Soft-tissue sarcomata are usually more diffuse. The skin and vessels overlying lipomata show no changes, even in the presence of a fairly large mass, whereas engorgement of the cutaneous vessels overlying sarcomata, while not always perceptible, when present, differentiates the latter. Lipomata may or may not be encapsulated.

Malignancy.—Lipomata are benign tumors. However, rare reports of malignant change must be noted. Ewing quotes Benel and Delachanel in describing a case in which the authors followed the myxomatous and sarcomatous transformation of a lipoma involving the sciatic nerve sheath which eventually produced lipomatous and sarcomatous metastases in lymph nodes and lungs. Stewart reported three cases which he classified as liposarcoma of bone, but in his report he indicated the very reasonable doubt which the diagnosis entailed. The diagnosis of liposarcoma must be made with a full understanding of its essential histogenesis. Fat cells originate from a connective tissue anlage in which the embryologic elements carry the potential factors for differentiation into fat cells. Liposarcoma can arise, not from mature fat cells, but from their embryologic, more fibrous, forms. Their ability to create adipose tissue in a metastatic focus is comprehensible only by this assumption.

In our series there were no tumors which could be classified as liposarcoma, although several in which lipomatous tissue was in close proximity to areas of sarcoma were suggestive. Less than 1 per cent of the cases were recurrent and these were always benign tumors, suggesting the great probability of incomplete primary removal. Multiple tumors may grow independently in different parts of the extremities with no apparent direct relationship to each other. However, some individuals act as though they possessed a generalized susceptibility to lipomata because of the numbers of such tumors they present.

Treatment.—Lipoma occurring in the subcutaneous tissues should be excised, if for no other reason than to confirm the diagnosis. Besides this, however, such a tumor visible or palpable on the body surface is invariably tampered with by the patient. Hence, infections in younger patients, and ulcerations in older ones are by no means rare. In the so called periosteal

lipoma, excision is imperative. The question of diagnosis is more essential, and the possibility of local skeletal deformity is always present. Intramuscular and intermuscular lipomata present individual problems—after diagnosis is confirmed, best by punch or incision biopsy. In these cases the probability of diagnostic error is greatest because of their clinical similarity to fibrosarcomata. When the presence of benign lipoma is established, the advantage of excision must be weighed against the disadvantage of postoperative dysfunction. If the tumor does not interfere with muscle function, or with the circulation of the extremity, it is better left alone. If it interferes sufficiently, wide excision including involved muscle tissue should be performed. Radiation has not as yet been proven effective for these neoplasms.

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BRIEF COMMUNICATIONS AND CASE REPORTS

MESENTERIC APOPLEXY*

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Case Report.—A female, aged 80, while sitting quietly at home was seized, on the evening of April 25, 1935, with acute, cramp-like, generalized abdominal pain. She went to the toilet immediately but passed neither feces nor gas, then, feeling very weak, she fainted. When seen a few moments later she had recovered consciousness, but was in a condition of collapse with pallor, cyanosis, and rapid, thready pulse, but no fever. Her abdomen was rigid and exceedingly tender throughout.

With the exception of an operation for acute suppurative appendicitis 20 years before, the patient had always been in good health. Convalescence was complicated by the presence of numerous peritoneal adhesions and required a long period of drainage.

For several years the patient had had occasional appearances of large subcutaneous ecchymotic spots, especially about the hands and fingers, which apparently represented the rupture of small superficial vessels, and of recent years she has shown some evidence of advancing arteriosclerosis and cardiac weakness. Blood pressure has ranged from 160/110 to 200/120.

The patient was put to bed following her seizure, and during the succeeding 24 hours, while her general condition improved, the abdomen remained very tender, somewhat rigid, and became greatly distended. There was no spontaneous passage of either feces or gas, although milk and molasses enemata and colonic irrigations succeeded in removing a little gas with a portion of inspissated feces. It was felt that the patient was suffering from acute intestinal obstruction, presumably due to the effect of her old operation and its concomitant adhesions. She was removed to the hospital the following evening. A flat film of the abdomen indicated fluid levels and was typical of acute obstruction.

Immediate operation was performed. A long right rectus incision was made, extending from above the umbilicus almost to the pubis. Markedly distended coils of intestine were immediately extruded and the excessive peritoneal fluid was decidedly blood stained. An attempt at exploration encountered, everywhere, numerous firm bands of adhesions which practically precluded satisfactory mobilization of the intestine. The blood in the peritoneal fluid seemed to be coming from the right upper quadrant. Exploration of this area revealed a mass which, following separation and division of adhesions, was found to consist of a massive hemorrhage between the leaves of the mesentery of the colon in the region of the hepatic flexure. The colon in this area appeared to be blackened and was markedly distended. It was apparent that spontaneous rupture of the colica dextra had occurred producing an hematoma and seriously compromising the blood supply to about six or eight inches of the hepatic flexure. The effect of this presumably was to produce evidence of intestinal obstruction, probably further enhanced by the presence of dense adhesions especially in this area. The leaves of the mesentery were separated and the clot removed. The original area of hemorrhage was not discovered. Several bleeding points in the mesenteric vessels were controlled.

* Presented before the New York Surgical Society, October 23, 1935.

Closer investigation of the segment of blackened gut showed that some of this appearance was due to the formation of a clot about the intestine which, when cleared away, showed the gut wall to be purplish but still viable.

Following the severance of constricting bands in the area, a cecostomy was performed at the lower angle of the wound, the peritoneal cavity evacuated of fluid and blood, and the abdomen closed.

The patient's recovery from the operation was slow and rather stormy. The cecostomy performed satisfactorily, the Pezzer catheter being removed on the eighth postoperative day. The temperature subsided to normal on the eleventh day and the patient was discharged on the thirty-first postoperative day. By this time, bowel movements were occurring normally and the discharge from the cecostomy wound was diminishing. This eventually closed spontaneously. Normal function of the bowel was satisfactorily established within two months after her discharge. The only complication in her subsequent course was a rather severe attack of herpes.

The accident from which this lady suffered is a clinical rarity. Hitherto but four cases of mesenteric apoplexy have been reported in medical literature.^{1, 2, 3, 4} In all four, rupture occurred in branches of the celiac axis. The vessels involved were the gastroduodenal, left gastro-epiploic, left gastric and right gastric. This is the only case so far reported of spontaneous rupture of an artery in the colic mesentery. The patient is the oldest to survive this accident. The ages of those previously reported were 27, 54, 57 and 60. All but the 27 year old patient suffered, as did the present patient, from definite arteriosclerotic changes associated with hypertension. In no case was the diagnosis made before operation.

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DISCUSSION.—DR. F. W. BANCROFT (New York) thought that frequently cases thought to be occlusion from within the vein were due to pressure from without. When an abdomen is opened, where there has previously been an abdominal incision and where there are intestinal adhesions, the pathology may not be recognized through a small abdominal incision. In freeing the adhesions a volvulus or a band may be separated which may have been the cause of presumed gangrene, and the occlusion of the vessel may be due to pressure from without, and not be a primary lesion within the vascular lumen. Furthermore, what is frequently considered to be a gangrene is in reality venous hyperemia. For instance, in gallbladder operations the impression is often created that there is gangrene of the gallbladder, whereas on microscopic examination of the gallbladder wall one is surprised to see marked engorgement of the vessels and hemorrhage into the tissues—and not, at that particular time, gangrene, but, instead, there was venous occlusion with arterial blood pumped in during the early process, with extravasation of blood into the tissues. When the pressure becomes high enough for arterial stasis,

then thrombosis occurs and gangrene results. Many cases considered to be beginning gangrene of the bowel are in reality probably instances of venous hyperemia.

In the case just reported, the blood clot was evacuated and the condition seems really to have been an apoplexy. However, it is conceivable that in a lesser stage of this particular type of extravasation of blood between the leaves of the mesentery there might have been a venous occlusion due either to pressure from without or to thrombosis from within, with secondary weeping eventually resulting in the formation of an hematoma.

DR. HOWARD LILIENTHAL (New York) said that, while not doubting it, diagnosis must have been difficult even after free exposure was obtained. The sudden onset was suggestive, but it was rather remarkable that there was not a continued free, alarming hemorrhage, considering that the patient was operated upon so soon after the accident.

DR. SEWARD ERDMAN (New York) had never understood quite how there could be enough pressure from hemorrhage to interfere with the viability of the part. How could the same pump mechanism keep pumping blood into an hematoma with sufficient force really to devitalize tissues, despite the fact that blood is imprisoned between different layers, and how could the arterial blood pressure be any higher at one end of the circuit than at the other?

DR. CUTLER said that he did not wish it to be understood that there was actual devitalization of the intestine, although this appeared to be so at first. That there should have been a certain amount of cyanosis of that loop of gut—which appeared to be the case—might readily be explained on the basis of the mass of arterial origin between the leaves of the mesentery, pressing upon and interfering with venous return. Had the mass not been quite so large, it might be assumed that there was sufficient circulation from the ends of the affected gut to overcome the discoloration, but there was an area of intestine fully eight inches in length which was definitely bluish, almost purplish, in color. Another factor may have been the nearby adhesions. The entire intestine was distended and there were numerous adhesions. It may be that some interference with the vascularity was produced by those two combined factors. The condition could not readily be explained on any other basis than mesenteric apoplexy, taking into account the sudden spontaneous onset and the development of massive hemorrhage within the leaves of the mesentery. Although the hemorrhage was somewhat controlled by its own pressure, it continued when the abdomen was opened so that ligation of bleeding arterial vessels was necessary. It was impossible, however, to identify the single large vessel from which the bleeding originally came. It was the continuous bleeding, slow and slight though it was, coming down from that part of the abdomen, that led to exploration of the area.

GASTROCHOLECYSTIC FISTULA *

VOMITING AND PASSAGE OF GALLSTONES PER RECTUM

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Case Report.—A female, aged 33, was admitted to Beekman Street Hospital July 25, 1935, with a history of right upper abdominal discomfort for two weeks. For the previous three days the pain had become progressively more severe and was associated

* Presented before the New York Surgical Society, October 9, 1935.

with repeated attacks of vomiting, during one of which she claims she vomited six or seven dark stones, each the size of a coffee bean or larger. Except for a three months' period of postprandial discomfort two years ago, eventually controlled by a careful Sippy regimen and bland diet, she had remained free from complaints until the present trouble.

Examination revealed a moderately obese Negress suffering from severe upper abdominal pain with a spastic right upper quadrant and distinct tenderness over the gallbladder region. Her temperature was 100° F.; white blood cells 12,600; P.N.L., 85 per cent. Her condition was considered to be one of cholelithiasis and acute cholecystitis. For the first 48 hours there was constant, severe, uncontrollable right upper quadrant colic associated with repeated vomiting. On the third day her symptoms suddenly ceased, and several hours later, in the course of a rectal examination, a gallstone 2.5 cm. in diameter was removed. The history of vomiting stones as well as the passing of a stone by rectum made the diagnosis of a fistulous communication between the gallbladder and gastro-intestinal tract evident. A dye test failed to reveal the gallbladder.

Exploration July 31, 1935, revealed a moderately thickened gallbladder containing no stones and with no evidence of recent intrinsic or extrinsic inflammation. The inner aspect of the neck of the gallbladder just distal to the cystic duct was intimately fused for a distance of 2 cm. to the superior and posterior aspect of the pyloric end of the stomach. The gallbladder was carefully separated from above downward until this attachment was reached, when it was opened a fistulous communication was exposed through which a probe was readily passed into the stomach. The cystic duct was occluded. The gallbladder was then cut away from the stomach, leaving a rather rigid opening 2 cm. in diameter. This was closed with difficulty by an inner mattress suture of chromic gut and an outer one of linen. The gallbladder was then removed. Some troublesome bleeding occurred in the region of the right hepatic duct which was controlled by three long artery clamps. These were left in situ because of the fear of compromising the duct in attempting to ligate the bleeding vessels. Gauze packing was placed around the clamps and a tube inserted into Morrison's pouch. On the fifth postoperative day, clamps and packing were removed, following which a thin, brownish, colon-smelling discharge appeared, suggesting a fecal leak. This continued for seven days, becoming thinner and less odorous, though more profuse. Methylene blue given by mouth appeared quite promptly in the wound, indicating that the suture closure had given way. Because of a conceivable duodenal leak the skin was protected by a copper powder and bronzing liquid, and suction was applied to the wound. There was no tendency to erosion of the skin. The patient's condition was improved rather than impaired. The discharge was acid; no pancreatic ferments were found. The fistula was evidently of gastric origin. The drainage became progressively less after the tenth postoperative day, the wound healed rapidly, and the patient was discharged on the twenty-third day after operation.

Although spontaneous internal cholecystoduodenal and cholecystocolic fistulae are not infrequently seen, cholecystogastric fistulae are apparently quite rare. Judd and Burden, in 1925, reported 153 cases of internal biliary fistulae operated upon at the Mayo Clinic, of which 117 communicated with the duodenum, four with the duodenum and colon, 26 with the colon, and only six with the stomach. Isolated cases have been reported by Ochsner, Snively, and Ranken. The vomiting of gallstones is apparently very unusual, and although suggestive of a gastric communication, is not necessarily so, for since bile is frequently regurgitated into the stomach it is conceivable that small gallstones could also be. It is interesting, that the original symptoms, two years prior to the admission of this patient, were distinctly of the peptic ulcer

type, suggesting the period when the fistulous communication was most probably being established.

DISCUSSION.—DR. RALPH COLP (New York) said that with the present early diagnosis of—and operation for—gallbladder disease these cases are rather infrequent. Doctor Mage's case was unique in that the diagnosis was made preoperatively because of the vomiting of gallstones and the passage of one by rectum. Another interesting feature is the fact that the patient complained of severe colicky pains and for four days vomited almost uncontrollably. Suddenly, with the coincidental passage of a gallstone by rectum, the vomiting ceased. It is barely possible, inasmuch as the findings at operation showed no acute pathology, that the acute symptoms were due to the presence of a low grade, intermittent intestinal obstruction caused by the stone in its passage through the small intestine. In the past few years at Mt. Sinai Hospital there have been five cases of intestinal obstruction caused by gallstones. In some, they were ordinary large stones; in other instances, the caluli had had an accretion of fecal material. In one of these cases, upon whom Doctor Klingenstein operated, it was possible to make a preoperative diagnosis of intestinal obstruction due to gallstone. The only measure taken in these cases was to relieve the intestinal obstruction by removing the stone. No further operation was performed for the fistula, which certainly must have been present, because the patients did not complain of any symptoms referable to the upper abdomen. In order to have a fistula, there must be obstruction to the cystic duct. Once perforation has occurred into an adjoining viscus the chances are probable that with evacuation and continuous drainage of the gallbladder, subsequent operation will be unnecessary.

LEIOMYOSARCOMA OF THE JEJUNUM *

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STATISTICS dealing with the frequency of occurrence of tumors in the small intestine exhibit a wide variation. Perhaps the most comprehensive study published in recent years is that of Raiford,¹ who collected a series of 986 tumors of the gastro-intestinal tract. Of these, 88, approximately 9 per cent, were in the small intestine, and 14 in the jejunum. None of the latter was a leiomyosarcoma, although there was one myoma and one spindle cell sarcoma. Joyce² cites among nine cases of small intestine tumors one leiomyoma of the jejunum which closely resembles the case about to be reported, but which was benign. Prey, Foster, and Dennis³ collected from the literature 61 cases of primary sarcoma of the duodenum and added a personal case. Forty-eight of these had an histologic classification. The great majority were lymphoblastoma, only four having been myosarcoma. Cabot,⁴ Cattell and Woodbridge,⁵ Bagozzi⁶ and others have reported single cases in recent years. Corner and Fairbanks⁷ state that the ratio of myosarcoma to other types in the small intestine is 2 to 63, while Speese⁸ places it at 1 to 96. Anderson and Doob⁹ found only 18 cases to have been reported in the literature from

* Read before the Philadelphia Academy of Surgery, May 13, 1935.

1875 to 1933, inclusive. In 13 of these in which the site was mentioned, ten were in the jejunum, one in the ileum and two in the duodenum. Metastases were reported in only four of this series. The incidence was greatest between the thirtieth and fiftieth years.

The case here described agrees with the majority of those encountered in that the cardinal symptom was bleeding from the bowel, that roentgenologic examination was of no help in the diagnosis, and that pain was a late manifestation. Obstruction appears to occur very infrequently. Perforation has been observed in several cases. The prognosis is guardedly good.

Case Report.—R. W., aged 20, a white, unmarried female, was admitted September 5, 1933, to the medical division of the Mt. Sinai Hospital with a diagnosis of secondary anemia after a hemorrhage from the bowel. After a short period of treatment she was transferred to a convalescent home. While there she began to experience pain in the left lower quadrant of the abdomen. She returned to the hospital on November 7, 1933. A sense of resistance was found in the area corresponding to that in which the pain was felt. This was considered to be due to a spastic colon or to a ptosed kidney. The usual examinations, including cystoscopy and barium enema were negative, except for occult blood in the stools and a ptosed colon. No tubercle bacilli were found in the feces. The patient was discharged improved after three weeks. She returned to the convalescent home, where she felt perfectly well until December 10, 1933, when she awakened with a throbbing sensation in the head. This passed off in a few hours but recurred next day. Her stools had been very dark for several days. She was put to bed and given a restricted diet. The color of her stools returned to normal. When, however, she resumed activity and a more liberal diet, her stools again became tarry, and her hemoglobin was found to be 40 per cent. She once more entered the hospital on December 17, 1933.

At this time general examination was again substantially negative. Her stools constantly contained occult blood, usually rated 4 plus, but occasionally declining to a trace. Gastro-intestinal roentgenograms were normal except for colonic ptosis. Proctoscopy and sigmoidoscopy were negative. With the aid of several transfusions her blood picture improved only slightly.

After nearly two months of treatment on the medical division, the patient again began to have pain in the left lower quadrant. The temperature became elevated, there was leukocytosis and a tender circumscribed mass became palpable. She was transferred to the surgical service of Dr. E. L. Eliason, and her abdomen opened on February 12, 1934, through a muscle-splitting incision over the mass. The latter was entered and found to contain a large quantity of pus with the odor characteristic of *B. coli*. The abscess was drained. No effort at exploration was made. The patient continued to pass blood by bowel, and was given transfusions from time to time. Pus drained from the abdominal incision continually. She frequently complained of severe colicky pains, but they were inconstant in location and irregular in occurrence. Although she improved somewhat, her stools were never free from considerable quantities of blood and it was finally decided to operate again.

The abdomen was opened, April 28, 1934, through a median incision. A mass was found consisting of two loops of jejunum and one of sigmoid bound together, with a tumor in one of the jejunal loops. The latter was in communication with a sinus which extended to the exterior through the first incision. The tumor was an irregular, nodular mass with an ulceration of the mucosa, and was evidently the source of the bleeding. The loops were dissected free, the tumor-bearing portion of the jejunum resected and a lateral anastomosis performed. Convalescence was relatively uneventful and the patient was discharged with both wounds healed some four weeks later. She has remained well. Bowels move frequently without laxatives. A gastro-intestinal roentgenologic study

made February 1, 1935, showed no abnormalities. Stools are free from blood and her blood count has returned to normal.

The patient died about September 1, 1935, of a recurrence of the original growth.

Pathologic Report by Dr. D. R. Meranze.—*Macroscopic*.—The specimen consists of a portion of the bowel and measures 25 cm. in length. Occupying one end of the bowel is a large tumor mass measuring 8 by 9 cm. which apparently springs from the entire circumference of the bowel and projecting into the lumen practically occludes it. The tumor mass is composed of a yellowish-white, firm and friable tissue, which has taken on a grossly ruffled appearance. The ruffled character is also evident in the two secondary tumor growths arising at the periphery of the original growth. The neoplastic involvement has in some regions extended to the serosa and produced nodular projections through it. Some portions of the tumor mass are markedly hemorrhagic. Other areas have a yellowish-white translucent aspect. About one-half of the upper portion of the tumor has ulcerated away. The lumen of the bowel below the tumor is filled with dark clotted blood. What is taken to be a node on the serosa is apparently infiltrated with the neoplastic tissue. In one region the tumor has apparently stimulated a marked fibrous reaction.

Microscopic.—The mucosa shows no primary neoplastic process. Some portions of

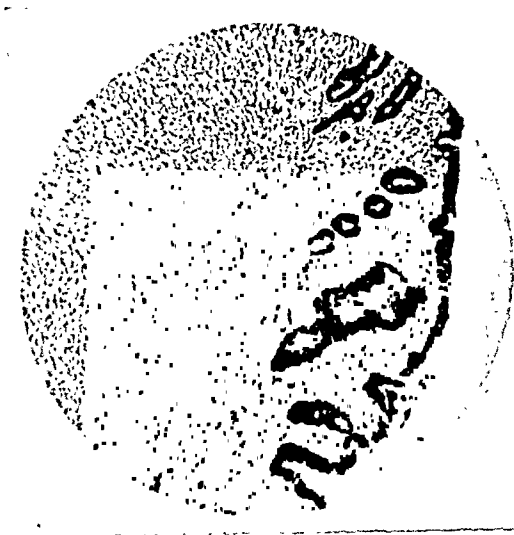


FIG. 1.—Low magnification.



FIG. 2.—High magnification.

Photomicrographs showing infiltrating character of growth.

it have undergone necrosis. A neoplastic process occupies the site of the muscle coats of the jejunum, and apparently is primary in this region. It consists of a spindle type cell, whose nuclei show considerable polymorphism and many mitoses. The process has infiltrated the submucosa and mucosa, replacing the layers and causing the necrosis described above. It has also penetrated the serosa and periserosal tissue, being present in what was thought to be a lymph node in the gross specimen. Many thin walled vessels traverse the neoplasm and hemorrhage is marked in many regions. In specially stained tissues this neoplastic tissue takes the stain in the manner of muscle cells (Figs. 1 and 2).

Diagnosis.—Primary leiomyosarcoma infiltrating all coats and extending into the periserosal tissues.

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INTESTINAL OBSTRUCTION FROM A FOOD BOLUS

TWO EPISODES IN THE SAME INDIVIDUAL

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INTESTINAL obstruction caused by a bolus of food is quite unusual. In a review of the literature in a 25 year period we have found no patient described in whom two distinct obstructions have been present at different intervals from such a cause. Chalmers⁸ patient had two intestinal obstructions seven years apart. The cause of the first was not stated, but the second was caused by a fig which had been swallowed whole. Elliott¹⁰ collected 39 cases of intestinal obstruction caused by food within the 22 year period from 1910 to 1932, and added one of his own.

He noted that some of the predisposing factors appeared to be: (1) Increased age with an atonic digestive tract and concomitant abdominal pathology such as (2) stricture or neoplasm, (3) the habit of swallowing food whole, and finally, (4) the drinking of a large quantity of water with meals which might cause swelling of vegetable fibers, with a resulting increased bulk sufficient to cause obstruction. Table I (Elliott¹⁰) illustrates the type of obstructive material and the number of cases in the series which he collected from the literature.

TABLE I

Obstructing Material	Number of Cases	Obstructing Material	Number of Cases
(1) Mushrooms.....	5	(9) Grapes.....	2
(2) Cherries (stones).....	4	(10) Poppy seeds.....	2
(3) Beans.....	4	(11) Ammunition bread.....	2
(4) Figs.....	3	(12) Sauerkraut.....	1
(5) Oats.....	3	(13) Gooseberries.....	1
(6) Potatoes.....	2	(14) Raisins.....	1
(7) Apples, pears and peas.....	2	(15) Half an orange.....	1
(8) Corn.....	2	(16) Popcorn.....	1
		(17) Bran.....	1

Table II shows the additional cases of bolus obstruction which have appeared in the literature since his report.

The most common site of obstruction from a food bolus is the terminal ileum, perforations are rare, and the symptoms usually come on within 12 hours after the material has been ingested. These are much the same as those noted in intestinal obstructions from any cause,³⁰ namely: pain, disten-

TABLE II

	Number of Cases	Causative Agent	Location of Obstruction
(1) Johnson ¹⁶	1	Apricot	Ileum
(2) McIvor ²³	1	Green corn	Not given
	1	Bran	Not given
(3) Anderson ⁴	1	Watermelon seeds	Rectum
(4) Lobsinger ²¹	1	Japanese persimmon	Jejunum
(5) Altman ³	1	Bone and peanut	Jejunum

tion, nausea and vomiting, and obstipation. Early relief of the obstruction is indicated.

Rarely a phytobezoar may pass out of its usual location in the stomach and cause an intestinal obstruction. Hart¹⁴ mentions two such cases. In one individual, exploration revealed a phytobezoar in the stomach and another in the ileum, which was causing intestinal obstruction and impending perforation. In the other case a man ate, for the first time in his life, a large quantity of persimmons. He soon felt "sick all over." This discomfort lasted four or five days and then gradually subsided. Eighteen months later a roentgenologic examination showed a gastric ulcer. Laparotomy revealed a benign gastric ulcer, which was excised, and a gastro-enterostomy was performed. The patient felt well for seven months when he was suddenly seized with severe cramps. A diagnosis of intestinal obstruction was made and at operation a phytobezoar was found in the jejunum a few inches from the gastro-enterostomy opening. The obstructing mass was removed and was found to consist of persimmon seeds and pulp. It had apparently been present approximately two years and three months. Balfour and Good⁵ quote Langenbuch who reported phytobezoars present simultaneously in the stomach and small intestine.

In general when intestinal obstruction is caused by phytobezoars there is a preceding history of gastro-intestinal distress for a period of weeks, or even years. Frequently the distress from the bezoar in the stomach simulates that of peptic ulcer, however, in the reported cases when the obstructing material passed into the small intestine, the severe cramps, prostration and other signs were prominent enough to warrant surgical intervention.

Case Report.—J. S., aged 68, was first examined because of an hyperfunctioning adenoma of the thyroid associated with an auricular fibrillation. These disorders were combined with coronary disease, indicated by inverted T-waves in leads II and III of the cardiogram. Because of the poor general condition and badly damaged heart, it was thought better to treat the patient medically. He was sent to the Wells County Hospital for several weeks' rest in bed, under which regimen he gradually improved.

He was very fond of apples and ate them frequently. His lower denture did not fit and he would not wear this plate when he ate and as a result he chewed his food very inadequately.

About six weeks after he was dismissed from the hospital, his physician stated that: "The day before becoming ill the patient had eaten apples after his evening meal. He had gone to bed and had awakened some hours later with severe cramping abdominal pain. Distention rapidly developed and peristaltic waves were visible through the abdom-

inal wall. Enemata were without effect." A diagnosis of intestinal obstruction was made. Abdominal exploration was performed at the Wells County Hospital.

Under ethylene anesthesia, a low right rectus incision disclosed an obstruction located in the ileum. Several proximal loops of intestine were red, engorged, and distended with gas and fecal material. An irregular mass approximately 6 by 5 by 4 cm., filled the lumen of the bowel. A Witzel type of enterostomy was performed, above the obstruction. After the distention was released it was possible by gentle manipulation to break up the bolus into small particles which it was thought would pass down the intestinal tract. The wound was closed. Fragments of the bolus that were examined when passed by the rectum, were pieces of apple. The patient made an uneventful convalescence.

For three months he remained well. He was then seized with intermittent abdominal cramps during the night. The bowels were moved inadequately with enemata. The symptoms of obstruction rapidly increased. At the end of 48 hours a second abdominal exploration was performed. The bolus had apparently passed along the small bowel, not completely occluding the lumen, until it came to an area where two loops were adherent. Here it became wedged and had caused a complete obstruction. The mass was broken up gently without opening the intestine, and a Witzel type enterostomy made in the most distended proximal loop.

The condition of the patient was poor when he left the operating table. The systolic pressure fell during the operation from 150 to 80. He succumbed the following day.

Postmortem examination demonstrated that the last obstruction and enterostomy tube were in the jejunum. The bowel contained pieces of vegetable material from 1 to 3 cm. in diameter which had formed the bolus. These could not be positively identified although they resembled raw potato. No neoplasm was found within the abdomen. There was bilateral hypostatic bronchopneumonia with pulmonary edema, and an old partial arteriosclerotic occlusion of the coronary arteries. There was an adenomatous hyperfunctioning thyroid.

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PLASTIC OPERATION ON THE QUADRICEPS EXTENSOR FOR OLD FRACTURE OF THE PATELLA*

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Case Report.—A male, aged 68, fell and fractured his right patella 32 years ago. It was sutured at the Pennsylvania Hospital. Ten years ago, in trying to save himself from falling, the same patella was again fractured. There was a separation of the fragments but the soft parts still gave fair stability and later on he was able to walk without crutches or cane. Last December, he fell on his right knee. All the structures were torn apart and he lost the power to extend his leg upon his thigh. He was able to walk with a cane.

At operation on February 27, 1935, the upper fragment was located at the junction of the middle and lower thirds of the femur. The lower fragment was below the level of the knee joint. An incision was made in the midline from the middle of the thigh to the lower edge of the lower fragment. Both fragments were exposed. The quadriceps muscle was so contracted and so resistant that the upper fragment could not be pulled down to anywhere near the lower fragment. Therefore the tendon and the aponeurosis of the rectus femoris was split down the middle and the outer half, including the vastus externus, cut away from the patella. At the upper end of this long median incision of the tendon, the inner half was cut across but not all the way through the vastus internus. A bundle of this muscle was left attached to the patella to provide it with a blood supply.

The upper fragment could then be pulled down to meet the lower fragment. The upper fragment was sawed across transversely near its lower edge, the cut being upwards and backwards. The upper edge of the lower fragment was sawed across transversely, the cut being upwards and backwards. The oblique cut surface of the upper fragment then overlapped the oblique cut surface of the lower fragment. Two holes were drilled through each fragment, one-third inch from the cut surface and the fragments were sutured firmly together with kangaroo tendon. A figure of eight suture of No. 2 chromic catgut was carried through the patellar tendon below and the quadriceps tendon at the upper edge of the patella. The cut ends of the tendon of the rectus femoris were sutured together and the capsule and tendon coverings sutured (Fig. 1). A plaster case was applied from the toes to the top of the thigh. This was cut down both sides so that the anterior shell could be removed for dressing and inspection. The knee joint was not moved for about six weeks. The limb was then removed from the plaster encasement, the knee joint moved through an arc of about 15° and the limb replaced in the case. Very gradually the range of motion was increased. The patient was able to go about with crutches and later with a cane. At the end of three months, a brace was substi-

* Presented before the Philadelphia Academy of Surgery, October 7, 1935.

tuted for the encasement. This has an interchangeable lock joint at the knee so that the range of motion can be regulated. He can now flex his knee almost to a right angle and extend it fully.

When sitting with his legs hanging over the edge of a table, he can easily extend his leg fully on his thigh, indicating good control by the quadriceps extensor. There

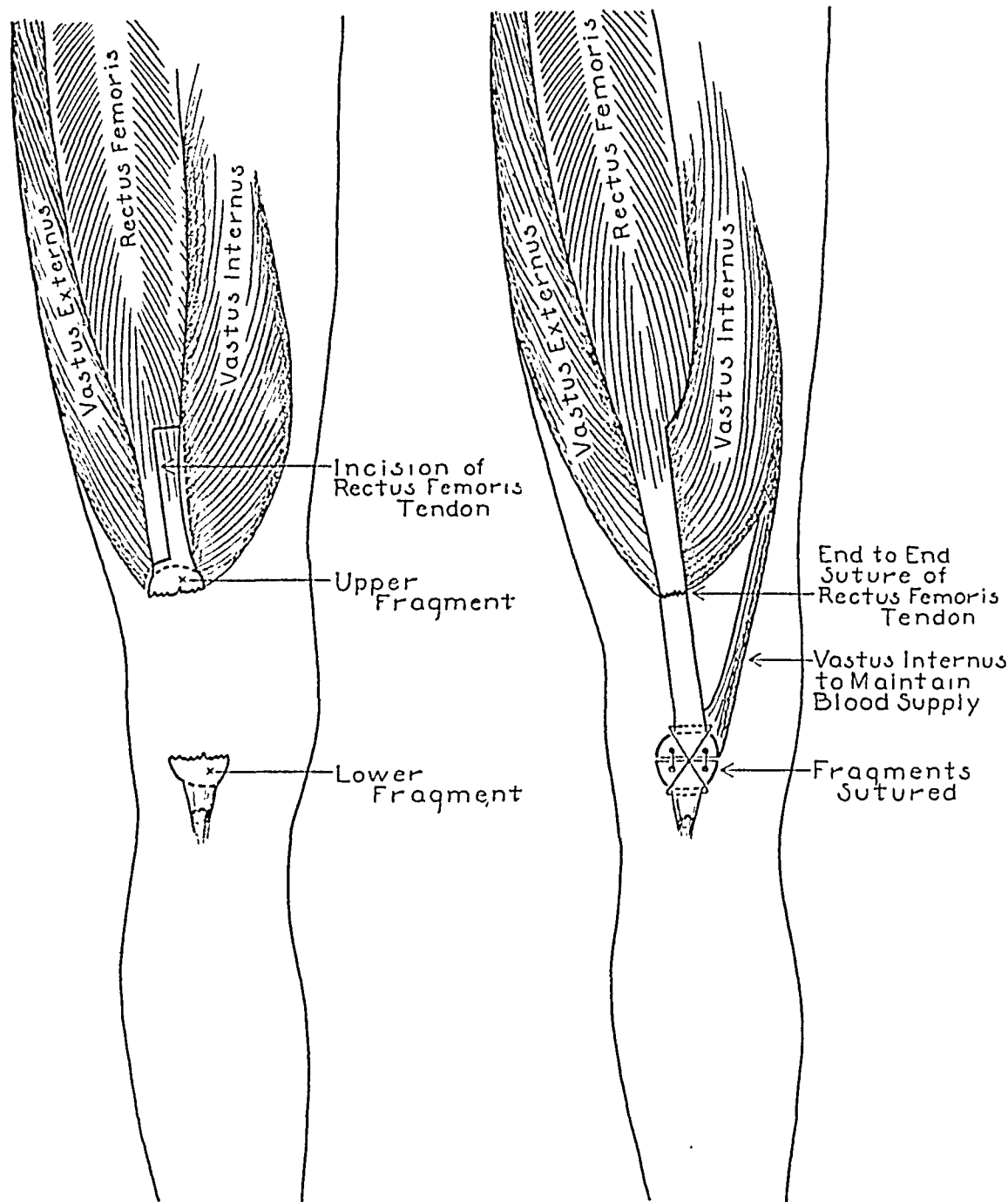


FIG. 1.—Illustrating the procedures described in the text, which were necessitated in order to approximate the fragments of the patella.

seems to be firm, dense, fibrous union of the fragments and the surrounding capsule. He walks easily and naturally without his brace but still wears it as a protection when he goes out of doors. This is adjusted to permit 45° of flexion at the knee. In another two months, it can probably be given up altogether.

A SIMPLE APPARATUS FOR THE CORRECTION OF FLEXION
CONTRACTURE OF THE KNEE

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VARIOUS devices, excellent in theory but for the most part too complicated in construction or applicability to be used in general practice, have been reported for the correction of knee flexion contractures. At the Pennsylvania Hospital we have employed a simple apparatus which has rendered surprisingly good results, can be easily assembled from the usual ward equipment, and introduces advantages not heretofore obtained from any other apparatus designed for the same purpose.

The only materials required for the construction of the appliance are a Balkan frame, turkish towel, towel spreader, rope, pulley, and weights (Fig. 1). To set up the apparatus the towel is folded in half longitudinally, slung about the foot, the ends attached to the spreader, and the towel suspended from the Balkan frame by a rope. The foot is maintained at right angles with the ankle by a row of safety pins approximating the outer margins of the towel. To hold the foot securely a second row of safety pins is placed through the towel along the dorsum of the foot. A cotton-gauze doughnut is placed under the heel and the dorsum of the foot protected by cotton batting. The extension rope is made secure to the base of the towel by a slip knot and large safety pin. The rope is then run over a pulley at the foot of the bed, and traction obtained by means of weights.

In our experience a four to six pound weight has been sufficient to maintain adequate extension. The maximum elevation of the ankle from the bed should not exceed that of the knee; otherwise, part of the weight of the extremity is supported by the hip. For the patient's comfort, the thigh may be partially supported by a pillow without detracting appreciably from the amount of extension.

The extension obtained is the resultant of the force of gravity on the extremity and the pull exerted by the weight attached at the base of the towel. This arrangement conveys purely passive motion to the part. The patient can, by means of a suspended cross-bar, greatly increase the extensive force by lifting himself free of the bed and shifting his weight to the foot suspended in the towel. Thus, the apparatus affords active as well as passive motion which is limited only by the patient's pain threshold.

We have found this apparatus of great value in contractions of the hamstring muscles, contractures resulting from burns, and those following effusion into the knee joint. It has particular merit in knee flexion deformities where skin lesions prohibit the use of skeletal traction, wedging plaster encasements, and other mechanical devices. It can be employed safely in the presence of skin infections, phlebitis, deep burns, naevi, varicosities, edema of the leg, *etc.*, where the above mentioned appliances are contraindicated.

Fig. 1.—Illustrating the general appearance of the extension apparatus after being assembled.



Physiotherapy can be instituted simultaneously with the use of the apparatus with absolutely no inconvenience. An added advantage is the fact that it can be employed continuously or intermittently with a remarkable degree of comfort to the patient.

We believe that this conservative form of treatment should be given a thorough trial in all cases of knee flexion contracture and internal derangements from a mechanical cause, excluding ankylosis of the knee joint, prior to the use of a wedging plaster case or the more radical methods of skeletal traction, or operative procedures.

ADDENDUM

Dr. DeWitt Stetten, of New York City, advises me that he described a clamp similar to mine in the October, 1928, issue of the American Journal of Surgery. I was not aware of his instrument but wish to acknowledge any priority which he may claim.

The clamp which I described in the March, 1936, issue of the ANNALS OF SURGERY, differs from that of Doctor Stetten's in that the serrations on the jaws run transversely, are deeper, and intermesh so that it is impossible for the bowel to slip. In addition, the adjusting nut enables one to have a uniform pressure exerted along the entire length of the crushing surface. My clamp also has a crushing surface three and one-half inches long, which is a distinct advantage in individuals with fat, thick abdominal walls.

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EDITORIAL ADDRESS

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MEMOIR

WILLIS FOREMAN WESTMORELAND

1864-1935

DR. WILLIS FOREMAN WESTMORELAND was born near Milner, Ga., July 22, 1864, and died December 4, 1935, at his home in Atlanta. His father was Dr. Willis Westmoreland, a fearless soldier and the ranking surgical officer of the Confederate forces.



WILLIS FOREMAN WESTMORELAND, M.D.

Doctor Westmoreland was educated at the Kirkwood Military Academy, Atlanta, Ga., and Georgetown University, Washington, D. C. He graduated in medicine at the Atlanta Medical College in 1885. The breadth of medical education in that era was exemplified by his father's insistence that two years

should be spent as a graduate assistant in the offices of the leading medical and surgical men of the nation. His first six months were with Dr. J. Solis Cohen in Philadelphia, the leading throat specialist of his day. Then to New York with Janeway and Loomis in medicine. His second year was in the marvelous surgical environment of Dr. Henry B. Sands and Dr. William T. Bull, whom he accompanied daily in the Roosevelt and New York Hospitals. Finally he became an assistant to Dr. Lewis A. Sayre and his distinguished son, the late Dr. Reginald H. Sayre. They were the leading orthopedic surgeons of that period. This branch of surgery made a special appeal to Doctor Westmoreland, and for many years he was preeminent in this section in the practice of orthopedics in connection with his general surgical work.

Following the death of his father in 1890, he was elected to succeed him as the Professor of the Principles and Practice of Surgery in the Atlanta Medical College, assuming the responsibilities of this position at the age of twenty-six, and for twenty-five years maintained with dignity and brilliancy all the traditions of a great family of physicians and surgeons. In 1915, he retired from active teaching and was appointed Professor Emeritus of Surgery at his Alma Mater.

In chronicling the achievements of an outstanding surgeon and teacher his success is measured by the ability to impress and inspire his students in the ideals of the art and science of surgery and of the observance of the high principles of conduct obtaining among his professional confreres.

There was no need of his subscribing to the oath of Hippocrates, nor the necessity of following written rules governing and guiding his sense of professional fairness and honesty. His scrupulous respect for the opinion of all medical men and his unswerving defense of them, whether prominent or obscure, endeared him to them in a manner impossible for the written word to describe.

His enthusiasm for everything pertaining to medicine was an inspiration to all of us, and in the development of medical education and medical organization his talents were unexcelled. In medical politics he was a fair but relentless opponent, and in defeat was as generous and magnanimous as in the full enjoyment of victory.

Doctor Westmoreland was an idealist in the practice of his profession. Never a moment in his life was given to the thought of making money. To him money was a fleeting thing to be used only as a means of giving happiness to his friends, and to hold the ever open hand to the sick and afflicted poor.

It may safely be said for him that surgery was, indeed, the Queen of the Arts.

WILLIAM S. GOLDSMITH



THE SURGICAL TREATMENT OF IRREMOVABLE CANCER OF THE PYLORIC SEGMENT OF THE STOMACH

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ALL recent statistics show that cancer of the stomach is the commonest malignant disease in man, and that in the majority of cases (60 per cent) the pyloric segment is the portion involved.

It is a deplorable fact that although growths situated here often manifest their presence at a comparatively early stage in the disease, giving rise to much gastric disturbance and obstructive symptoms, such a large proportion of them prove to be irremovable when the abdomen is opened. My own figures show that in less than 30 per cent of the cases submitted to operation can any attempt at radical cure be made, and that even when this is feasible the prognosis is less favorable than with cancers situated in the body of the stomach.

Pyloric growths invade the regional lymph nodes rapidly and extensively, and fixation to or penetration of adjacent viscera, such as the pancreas, occurs early in the course of the disease.

In borderline cases it is often exceedingly difficult to ascertain whether growths situated in the pyloric portion of the stomach are resectable or not until full anesthesia has been achieved and until the body of the stomach has been transected and a determined effort made to mobilize the affected segment together with the first part of the duodenum. In those cases in which this has been attempted and in which the growth has proved to be irremovable, the operation should be completed by adopting the method about to be described.

It is proposed to discuss here only the treatment of those cases which have been deemed operable and in which, after exploration, it is found that the growth cannot be resected. In such circumstances the aim of any operation which is undertaken is to prevent the patient from starving to death; to prolong his life, meanwhile rendering him more comfortable as far as his digestion is concerned; to ward off or at least postpone the advent of serious complications such as profuse hemorrhage, perforation, or severe toxemia; and to ensure, as far as possible, that when death does occur it is the outcome of secondary implants in the liver (which produce little pain) rather than of obstruction with its tormenting agonies.

Although hitherto the operation recommended for the type of case under discussion has been posterior or preferably anterior gastrojejunostomy, some operation based on the principle of Devine's,¹ which, in my opinion, best ful-

fills all requirements, is now more generally practiced for the following reasons:

(1) The death rate is no higher than that which follows the simpler short circuiting operation; in fact in my own series of 13 cases treated by this method or some modification of it, there has been no immediate mortality.

(2) The expectancy of life is prolonged. Where gastrojejunostomy has been performed it has been shown that patients usually live for four or five months longer than where simple exploration only is undertaken; but by the procedure here advocated the length of the patient's life may be increased by several months or, in exceptional cases, even years.

(3) The patient is prevented from dying of obstruction, as the gastroenteric stoma is very large and is widely removed from the primary growth which is excluded. Where, however, a gastrojejunostomy is performed, the stoma is apt to become occluded by the growth which spreads into the body of the stomach from the pyloric region, or to become compressed by metastatic nodes in the mesocolon or great omentum.

In performing a gastrojejunostomy there is also a tendency to place the opening too high up in the body of the stomach in order to ensure that the anastomosis is as far removed as possible from the involved portion of the stomach, often resulting in a poorly functioning stoma which affords but little relief.

(4) The immediate postoperative results are eminently satisfactory; it is at once possible to administer fluid nourishment by mouth in unstinted quantities; appetite is restored; cachexia disappears; and the patient's general health is greatly improved, often so much so, in fact, that in some cases which survive for longer than a year doubt may arise as to the correctness of the diagnosis made at the time of the original exploration.

The following is a brief description of Devine's technic with certain personal modifications which have been introduced in order to render the operation both simpler and quicker.

An injection of omnopon, gr. 2/3, and scopolamine, gr. 1/150, is given about 40 minutes before the operation, which is then, as a rule, performed under local anesthesia.

A midline epigastric incision, extending from the xiphisternum to the umbilicus, is the one generally employed, as it is easy to make and easy to close, and it affords ample and ready access to the stomach.

The stomach is then carefully inspected and palpated, and the exact position of the growth, the amount of stomach involved, and the extent of extragastric spread and lymphatic involvement are ascertained.

If, after methodical exploration, a radical gastric resection is considered to be inadvisable, or even impossible owing to the nature of the pyloric growth, but the remaining portion of the stomach is found to be healthy, the body of the stomach should be transected, the pyloric segment excluded, and the operation completed by performing an end-to-side gastrojejunostomy by the antecolic or retrocolic method.

The first step in the operation is the ligation of the main branches of the

right and left gastric arteries, and the freeing of the gastrohepatic omentum from the lesser curvature of the stomach, after which the gastrocolic omentum is widely ligated along the greater curvature so that the body of the stomach may be lifted up and its under surface inspected, any adhesions which may exist here being freed.

The field of operation is carefully packed off with warm Cripps' pads and macintosh sheeting, and a large roll of gauze is introduced into the lesser sac behind the stomach, after which a Friedrich-Petz clamp is applied high up on the body of the stomach from the greater to the lesser curvature, and as far away as possible from the growth in the pyloric segment. The instrument is forced home, the stomach is crushed, and the two rows of clips are inserted with mechanical precision and neatness (Fig. 1).

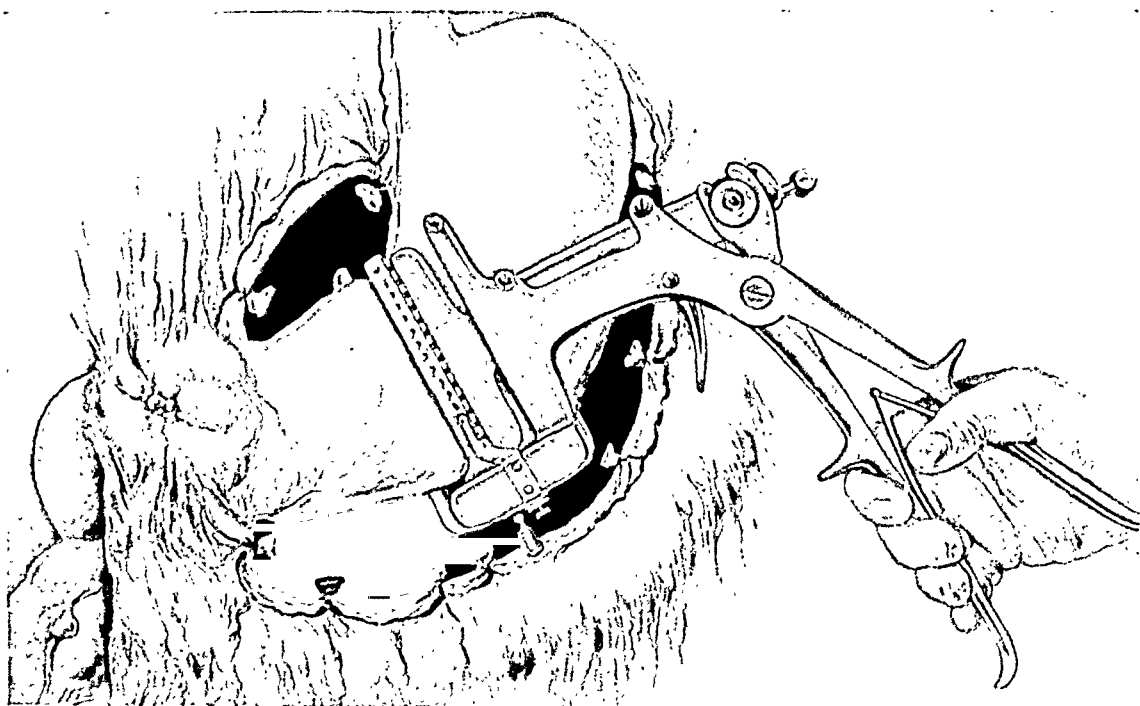


FIG. 1.—The Friedrich-Petz clamp is applied to the body of the stomach, well away from the growth, and the two rows of metal clips are inserted by forcing the instrument home.

After removing the clamp, two pairs of Allis forceps are applied to the lesser curvature and two pairs to the greater curvature, about one inch away from the crushed portion of stomach. A Sargent retractor is then passed immediately behind the grooved area so that the stomach can be transected between the two rows of clips with a Post electric cautery, the retractor meanwhile affording a firm base upon which to divide the stomach and also protecting the underlying pancreas from injury (Fig. 2).

The pyloric stump is then picked up with Allis forceps, and the crushed end with its single row of clips is invaginated with a continuous Lembert suture of No. 0 20-day chromic catgut, the suture line being further reinforced with a series of closely applied interrupted silk sutures which in turn are buried with a Cushing right-angled stitch of fine silk (Fig. 3).

Thus the pyloric pouch in which the growth is contained and excluded,

when securely closed in this way, presents a smooth, even surface, thereby preventing the subsequent formation of adhesions.

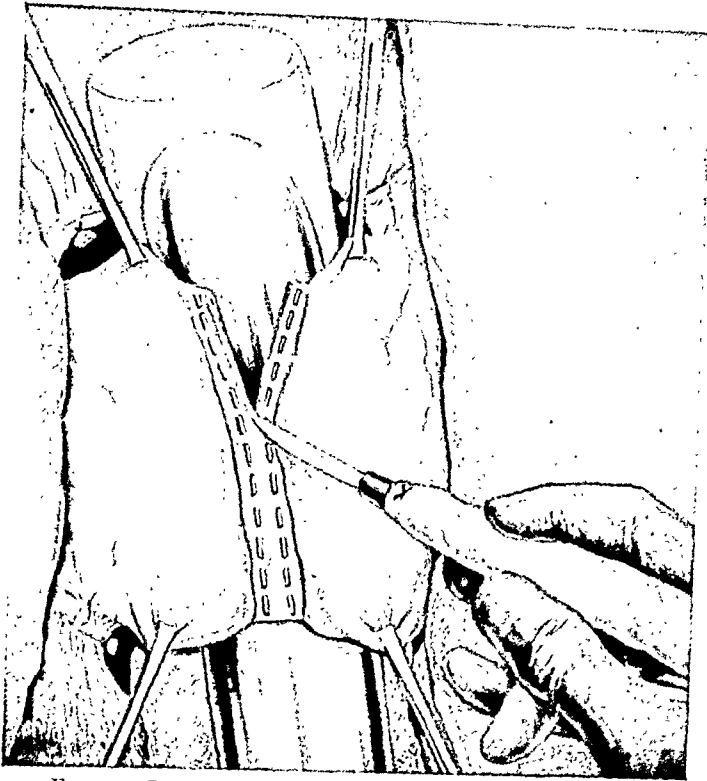


FIG. 2.—Transection of the body of the stomach between the two rows of metal clips, by means of a Post electric cauterizer. Note the position of the Sargent retractor.

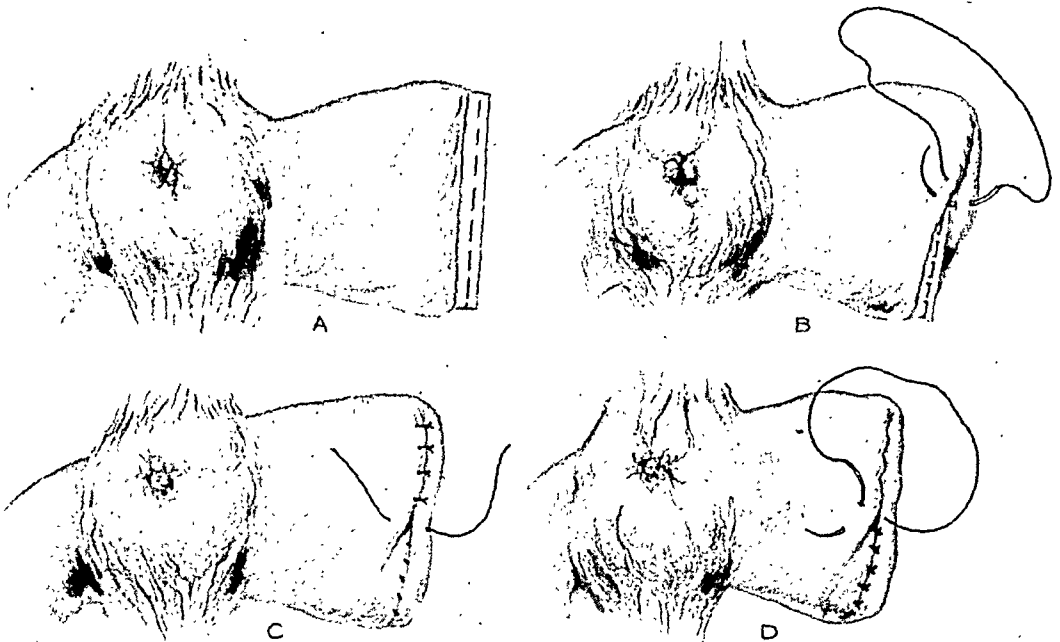


FIG. 3.—Closing the pyloric end of the stomach by means of a series of sutures.

After this step in the operation, the surgeon has to decide whether the anastomosis between the proximal cut end of the stomach and the proximal



FIG. 4.—Exclusion of the growth in the pyloric segment of the stomach, followed by end-to-side anastomosis by the posterior Pólya method.



FIG. 5.—Exclusion of the growth in the pyloric segment of the stomach, followed by the anterior method of anastomosis with entero-anastomosis as recommended by Balfour.

jejunum should be completed by the anterior or by the posterior Pólya method. In the majority of cases the posterior method is both feasible and preferable; but where the mesocolon is very short; where the vascular arches in the mesocolon are numerous or anomalous; where the first few inches of the proximal jejunum are tethered to the mesocolon by developmental or inflammatory bands or adhesions; where enlarged nodes are found to be present in the mesocolon; or where the transection has been performed very high up in the body of the stomach, the anterior method, as practiced by Balfour, has usually proved to be more simple and more satisfactory.

In the posterior operation a fairly large opening is made in the mesocolon, to the left of the middle colic artery, and after identifying the duodenojejunal flexure the first portion of the proximal jejunum is drawn through this opening into the supracolic compartment. The left hand edge of the opening in the mesocolon is sutured to the posterior aspect of the stomach before the anastomosis is commenced, and the right hand edge of the opening is sutured to the anterior aspect of the stomach after the anastomosis is completed.

A portion of the proximal jejunum, some six to eight inches from the flexure, is then applied to the cut end of the stomach from the lesser to the greater curvature, and after trimming away the crushed area of stomach with its contained clips, the anastomosis is performed in the usual manner, without the aid of clamps (Fig. 4).

In the anterior operation the portion of jejunum selected for the anastomosis with the stomach should be some 12 inches or so from the duodenojejunal flexure, and this is applied from the lesser to the greater curvature. When the row of clips which closes the stomach has been trimmed away, the anastomosis between the cut end of the stomach and the jejunum is performed, as in the operation of gastrojejunostomy.

At the completion of this operation a small entero-anastomosis is made between the afferent and efferent limbs of the jejunum, usually at a point about two inches above the duodenojejunal flexure (Fig. 5).

The abdominal wound is then closed with two rows of continuous sutures of No. 1 chromic catgut, and further reinforced with supporting sutures of silkworm gut to guard against the possibility of wound dehiscence, the skin edges being approximated with interrupted sutures of fine silk.

REFERENCE

- ¹ Devine, H. B.: Basic Principles and Supreme Difficulties in Gastric Surgery. Surg., Gynec., and Obst., vol. 40, pp. 1-16, January, 1925.

MYCOTIC INFECTION OF THE STOMACH

REPORT OF A CASE WITH PERFORATION

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MYCOTIC infections of the stomach are so infrequent and their pathogenicity so little understood that additional information on the subject is desirable. We wish to present a case of gastric fistula due to a mycotic infection of the stomach, a complication that does not seem to have been reported previously.

While the consensus of opinion is that fungi can cause an infection of the gastric mucosa, such as gastritis,³³ and can go on to ulceration,^{1a, 13, 20, 23, 36} yet there are some investigators^{28, 2, 34, 17} who attach little or no importance to the presence of fungi in the stomach. In evaluating the significance of fungi in any case, one must be certain that the organisms were permanently growing in the stomach and were not carried there as contaminants of food or of the gastric tube when it passed through the pharynx. Fungi are frequently found in the mouth probably because of their widespread distribution in food and air; according to Merke²⁴ and Brunstein⁷ molds are found in 40 per cent of the buccal cavities of normal people. There are no reports, however, showing the incidence of fungi in both the stomachs and buccal cavities of the same patients. Because of the swallowing of saliva and food, it would seem logical that fungi would be found in the stomachs of the patients who have molds in the mouth.

Cafasso,⁹ Hartwich,¹² Moppert and Kagan²⁶ examined stomach aspirations and found fungi in 40 to 60 per cent of their cases. Crasset found molds in 20 of 30 stomachs examined at autopsy. Cushing and Livingood¹¹ found that the duodenal contents during the interdigestive period were sterile; Ricer³¹ and Henning,¹⁵ however, found a low incidence of molds in duodenal ulcers.

In early mycotic gastritis, a thick membrane of fungi is found lying on a seemingly intact mucosa. Because of trauma or local vascular damage such as ischemia or hemorrhage, the organisms may cause a superficial ulceration in the underlying tissue.^{1b, 4, 12, 21, 27} They may penetrate to the muscular layer⁵ or serosa.²² The ulcerations may be either single or multiple, and they may vary in size from 1 Mm. to a lesion involving the whole stomach. The distinctive feature of these ulcers, as seen at operation, is the presence of a necrotic discolored membrane over the base and the sometimes brown-

ish granular appearance of the ulcer edges. Whenever fungi are found on microscopic examination in ulcers of this description, their presence is most significant.^{4, 9, 12, 13, 14, 24, 37}

Fungi in ulcers appear as scattered branching threads with globoid swellings devoid of fructification forms, lying in the superficial necrotic layer and contiguous intracellular spaces. Castellani and Chalmers¹⁰ have shown that fungi often lose their characteristic morphology when growing parasitically in the tissues; therefore, many mycelial threads may be seen with but few oval, yeast-like bodies. This change has also been observed by Singer³³ and Von Meyenburg,³⁷ who, like ourselves, obtained abundant typical growths of fungi when tissues were transplanted to acid media favorable to the growth of fungi and in which they grow best, but their abundance in achlorhydria is probably due to symbiotic growth with the many other organisms commonly found in gastric juice devoid of hydrochloric acid.

Nye, *et al.*,²⁹ examined stools of patients in their series and found fungi in 42 per cent. The cultures, however, were not considered positive unless there were 10 or more colonies of fungi per plate, thus reducing the incidence to 15 per cent. Most of these were *Parasaccharomyces ashfordi*. The incidence did not seem to be influenced by the gastric acidity.

Actinomycotic infections of the stomach are rare.^{32, 41, 18} The only distinctive feature is the presence of ray fungi in the wound scrapings. Blain⁶ reports a death from actinomycosis three months after a subtotal gastrectomy for a seemingly grossly malignant ulcer of the lesser curvature of the stomach. No fistula developed at any time. When the autopsy showed many actinomycotic hepatic abscesses, the stomach was sectioned again. Out of 330 slides, 12 were found to have ray fungi scattered in the periphery of the ulcer.

Classification of fungi is still so complex that identification of organisms isolated from ulcers is often difficult. Nye, *et al.*,²⁹ and Meyer²⁵ believe that the various generic names represent the same organism: *i.e.*, *Oidium*, *Monilia*, *Saccharomyces*, *Endomyces*, *Parasaccharomyces*, and *Blastomyces*. Meyer²⁵ says that the various bizarre forms cultured by the many authors are probably the same organism which has been modified by the hydrogen ion concentration of the culture and by the type of media used. The majority of cases where fungi were mentioned were due to *Monilia*, and a few were due to *Aspergillus*. These two organisms were predominant, but there were also scattered colonies of *Streptothrix* and *sarcinae*.

The symptoms of mycotic infections of the stomach are so like those of other acute infections²⁵ that preoperative diagnosis has never been made. Vomiting of blood is an almost constant characteristic of a fungous infection, and, of course, the finding of strands of molds in the vomitus or in the aspirated gastric contents is suggestive of the diagnosis. Even operative findings are so insignificant that diagnosis is difficult. The distribution of the possible sites of the ulcer is the same as that for round gastric ulcer.

Examination of biopsy, as in the case we will report, may be the first clue to the diagnosis.

The prognosis in mycotic infections cannot be determined inasmuch as a preoperative diagnosis has never been made. In mycotic ulcers recognized after operation, no untoward effects developed which might be attributed to fungi. Should a rare actinomycotic ulcer be found in the stomach, the prognosis is deferred since microscopic metastasis to the liver may have occurred.

CASE REPORT

M. M., Negress, 24 years of age, a native of Nova Scotia until 1933, was admitted to the Beth Israel Hospital May 6, 1934.

Past History.—Ten months previously, the patient was treated at the Boston Dispensary for chronic lymphatic leukemia of three years' duration.

Present Illness.—Increasing weakness, loss of 37 pounds, vertigo and anorexia. For six weeks, she has had epigastric distress after eating which was sometimes accompanied by nausea and vomiting; the vomitus consisted of blood-streaked food. Dyspnea with palpitation on exertion and a slightly productive cough. There was edema of the ankles. No melena was present. Amenorrhea for five months which was preceded by marked menorrhagia for one and one-half years. On one occasion, there was painless hematuria.

Physical Examination.—Temperature, 101° F. Mucous membranes, pale. Chest, negative. The heart had a short puffing diastolic pulmonic murmur. The only peripheral lymph nodes felt were a few in the right groin and a non-tender, firm node measuring 2 cm. in the right axilla. The abdomen was slightly rounded without tenderness or spasm. The liver edge was sharp and displaced downward to the level of the umbilicus. The spleen extended below the crest of the ilium. The erythrocyte count was 2,300,000; hemoglobin, 45 per cent. Leukocyte count, 14,250; 84 per cent lymphocytes, 14 per cent polymorphonuclear neutrophils and 2 per cent large monocytes. There were no abnormal cells. Platelets, 399,600 per cmm. Icteric index, 11.25. Hinton, Kahn, and Wassermann reactions, negative. The basal metabolic rate varied from +18 to +13. Sedimentation index, 0.18.

Clinical Progress.—Two days after admission, the patient developed a throbbing ache in the right upper quadrant of the abdomen which reached its maximum in 24 hours. Examination revealed an unaltered liver dulness with marked tenderness and spasm in the medial half of the right hypochondrium. During the next three days, the pain was localized over a well defined, rounded mass under the right costal margin, measuring three inches in diameter, which was firm and very tender. The rest of the abdomen was slightly distended but otherwise negative. During the next two weeks, the temperature varied around 104° F. A laparotomy was then performed with a preoperative diagnosis of an intra-abdominal abscess, the etiology of which was obscure.

Operation.—A four inch paramedian incision was made over the slightly elevated mass in the right upper quadrant of the abdomen. Considerable edema of the muscle and preperitoneal tissue was encountered. Immediately after the parietal peritoneum was opened, a large cavity was entered lined by a thick wall of brownish necrotic tissue without any frank purulent manifestations. The walls were formed by the gall-bladder and the right lobe of the liver above, and by inflammatory tissue which was difficult of recognition for the rest of its circumference. Cultures were taken; a small amount of necrotic tissue was removed for examination. A cigarette drain was placed down to the center of the inflammatory area without any further investigation of its depths.

For 48 hours after the operation, there was a slight seropurulent drainage. After the drains were removed on the second postoperative day, a large amount of watery fluid resembling gastric juice welled up in the wound. Food was seen to exude shortly after ingestion. During the postoperative course, the patient had a sustained temperature of 104° to 106° F. She developed pulmonary congestion and died 14 days after operation. During this period the erythrocyte count was 2,550,000, hemoglobin was 55 per cent; the leukocyte count gradually dropped to 7,000 with 55 per cent lymphocytes and 45 per cent polymorphonuclear cells. The van den Bergh rose gradually to 3.04 mg.

Cultures of peritoneum taken at the time of operation showed a moderate growth of *Staphylococcus albus*. Pathologic examination of the tissue removed at operation from the abscess wall showed that it consisted chiefly of necrotic connective tissue, in which could be seen many colonies of innumerable gram-positive filaments having spheres and club-shaped bodies at their ends. In places, the entire abscess wall appeared to be

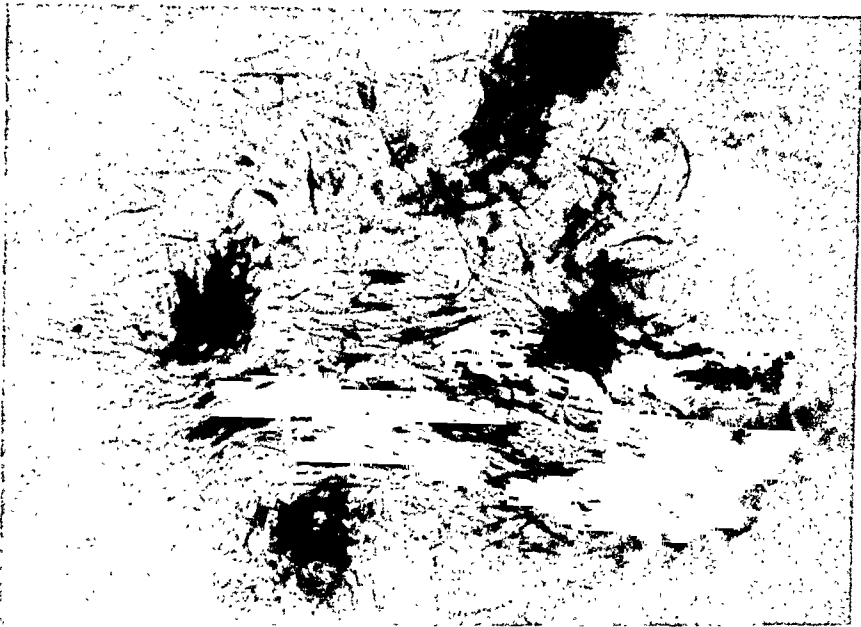


FIG. 1.—Section through the wall of the gastric fistula showing mycotic filaments and occasional ovoid bodies ($\times 325$).

made up of a network of these gram-positive filaments of fungi (Fig. 1). External to the abscess wall, there was a large amount of fibrin enmeshing innumerable lymphocytes, monocytes, polymorphonuclear leukocytes and occasional eosinophils.

On the fourth postoperative day, a punch biopsy was taken from the depths of the wound. Dr. Leo Rane reported that the biopsy gave a heavy growth of *Monilia albicans*. Repeated analyses of the abundant fluid in the fistulous tract revealed no free acid; the total acidity averaged 33 units. Lipase and rennin enzyme tests were positive, and trypsin and amylase tests were negative.

Autopsy Report.—The autopsy was performed three hours after death. The pertinent findings were reported by Dr. Monroe Schlesinger and Dr. Stanley Frehling. There was marked pitting edema from the toes to the vulva. Several discreet nodes, some of which measured 3 cm. in diameter, were found in the right axilla. There was a gaping high right rectus incision which communicated with the greater curvature of the stomach through a fistulous tract; the skin around the incision was slightly reddened with no digestion of the edges. The walls of the fistula were composed of the hepatic flexure of the colon, the inferior surface of the liver, the gallbladder, the first portion of the duodenum, and a greatly indurated hepatocolic omentum. The fistula was well localized by the indurated fibrotic tissue which filled the interstices between the above

mentioned organs. The rest of the peritoneum was normal. The fistula which was 6 cm. in diameter opened into the stomach at the greater curvature about 2.5 cm. above the pyloric ring, and extended in saddle-bag fashion along the posterior and anterior surfaces. There was marked edema of the mucosa surrounding the opening, with undermining of the edges. Distally, the mucosa was yellowish-brown and quite edematous so that the usual folds were obliterated. Elsewhere, the rugae were not unusual except for numerous petechial hemorrhages.

The superior wall of the hepatic flexure of the colon was involved in the induration for a length of 5 cm. At the middle of the indurated area the overlying mucosa had an irregular ulceration 1 cm. in diameter. The ulcer edges were slightly thickened and the base was formed by a septum of fibrous tissue 2 Mm. in thickness which completely replaced the muscle wall. No evidence of communication was found between the fistula and lumen of the colon.

The liver weighed 2,160 Gm., having a uniform light yellowish-brown color. The surface was smooth except on the inferior surface where there was a ragged grayish-green area measuring 10 by 3 cm., marking its apposition to the fistula. The spleen weighed 1,020 Gm. and had an area of perisplenitis 7 cm. in diameter at the upper pole. The mesenteric lymph nodes were enlarged to 2.5 cm. and were discreet. Similar enlarged nodes were found in the mediastinum. Both lungs showed marked atelectasis with numerous small petechial hemorrhages. The bone marrow obtained from the femur and from the ribs had a serosanguineous appearance.

Microscopic sections of the stomach were essentially normal except for an area about 3 cm. in width which surrounded the fistulous opening. Here the submucosa and serosa were thickened and fibrosed; the mucosa showed marked edema and the muscularis was practically unchanged. The superficial tissue of the sinus tract was necrotic and had a slight leukocytic infiltration. There were numerous bacteria, chiefly long, tortuous forms with occasional branching. The underlying zone was less necrotic although it contained many of the same filaments which were shorter than those found in the superficial tissue. Several small vessels filled with a fibrin thrombosis were present at the border of the necrotic zone. There was a remarkably small amount of inflammatory reaction in the adjacent tissue considering the marked degree of necrosis.

Sections through the hepatic flexure of the colon showed that the mucosa ended abruptly at the ulcer. The mucosa and submucosa were thickened and were infiltrated with closely placed, small round cells, fibroblasts, and scattered eosinophils. The floor of the ulcer was almost entirely composed of a thick layer of dense fibrous tissue which had replaced the wall of the colon at this point, and was blended with the pericolic induration.

Sections of the spleen showed a diffuse fibrosis of both the pulp and capsule. The corpuscles were poorly defined. There was no unusual cellular infiltration, and there was a scarcity of lymphocytes throughout.

Sections through the liver were essentially normal except for the area marking the fistula. This area showed a necrotic superficial layer composed entirely of disintegrated eosinophilic cells intermingled with a large number of rod-shaped organisms. Under this, there was a thin zone of fibrinous infiltration covering a strata of liver in which there was central degeneration varying from fatty infiltration to definite necrosis. Here also were seen a moderate number of rod-shaped organisms. The periphery of the inflammatory area, which was 2 cm. from the fistula, showed a moderate degree of portal fibrosis and lymphocytic infiltration.

Many lymph nodes showed a marked fibrosis which obscured the stroma. This appeared as a tremendous thickening of the septae of the nodes. The intervening sinusoids were almost empty, containing only a sprinkling of normal appearing lymphocytes and a few reticulum cells. Other nodes were not fibrosed; they also had a loose empty structure with very few cells.

Diagnosis.—Gastric fistula with mycotic infection, fibrosis and enlargement of spleen and lymph nodes, bilateral pulmonary atelectasis and congestion, focal necrosis of the lungs.

DISCUSSION.—We feel that this is a case of primary mycotic infection of the stomach with perforation and fistula formation.

Prior to operation, we considered that the abdominal abscess might be caused by the degeneration of lymphatic tissue; however, the absence of hypertrophied rugae as well as the absence of foci of lymphatic tissue and of any other signs of leukemic infiltration of the stomach or of the perigastric tissue, contra-indicates such an etiology.

While we cannot explain the healed small ulcer at the hepatic flexure, yet there was no evidence that it had perforated, and no *Bacillus coli* could be found. The question may be raised as to whether *Bacillus coli* might not have been suppressed by fungi entering from the colon; no record could be found in the literature of a pericolic or perigastric abscess due to any cause in which *Bacillus coli* had been outgrown by fungi.

The six weeks of epigastric distress was undoubtedly due to the lesion found at operation. When the peritoneum was opened, an area of brown necrotic induration was found without any frank purulent manifestations. There was no evidence of the presence of gastric, duodenal, or colonic contents. While cigarette wicks were used for drainage, these wicks could not have caused the perforation since they were placed at least 5 cm. from the base of the indurated area. The perforation, we feel, was spontaneous, since gastric contents appeared later than 48 hours after operation.

There was no histologic evidence of either a benign or malignant ulceration of the stomach. Moreover, simple round ulcers are commonly found on the lesser curvature of the stomach, but in this case the entrance of the fistula was at the greater curvature. While a malignant ulceration might take place at the greater curvature, no microscopic evidence of any such lesion could be demonstrated.

While one culture taken at operation showed staphylococcus albus, this was probably due to a contamination since no similar culture was obtained subsequently.

The small piece of tissue which was removed from the abscess wall was necrotic with many fungi; in fact, the entire abscess wall in places appeared to be made up of these fungi. Four days later biopsy was repeated and this again showed a heavy growth of *Monilia albicans*. Moreover, the microscopic examination of the stomach sections showed that the superficial tissue of the sinus was markedly necrotic with only a slight leukocytic infiltration, and, on the other hand, many mycotic organisms. There was very little inflammatory reaction in the adjacent tissue considering the marked degree of necrosis which is typical of mycotic ulceration.

The presence of numerous fungi which on culture yielded an abundant growth of *Monilia albicans*, together with the lack of evidence at operation

of a pyogenic abscess, leads us to conclude that the patient had a mycotic ulceration of the stomach which perforated with a resulting fistula.

SUMMARY AND CONCLUSIONS

(1) This is a case report of a patient who had an abdominal abscess with a gastric fistula.

(2) The presence of many fungi in the abscess and the fistula, the absence of histologic evidence of a pyogenic etiology, and our inability to demonstrate any other etiology warrants the conclusion that the ulceration was due to the fungi.

(3) That fungi may cause gastric ulcerations has already been noted but that the process may go on to fistula formation has not been reported previously.

(4) The almost complete absence of microscopic evidence of leukemia at autopsy when clinical evidence warranted such a diagnosis cannot be explained. It was probably due to a state of organic remission of the chronic lymphatic leukemia. Whether or not the terminal fever played a part in the remission is questionable.

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PATHOLOGIC CHANGES IN EXTERIORIZED GASTRO-INTESTINAL GRAFTS

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PART I.—EXTERIORIZED BOWEL.—In the course of certain experiments dealing with the physiology of exteriorized bowel¹ the question of pathologic change has been raised with sufficient frequency to merit its detailed description. This paper will attempt to describe the changes taking place in the morphology of various portions of the tract under this and other atypical conditions.

The conditions under which the first group of experiments were performed, that is, with exteriorized bowel, will be considered first. The method of preparation is as follows:

A segment of the gastro-intestinal tract (stomach, small intestine or colon) is isolated and a portion supplied by a single vascular arch resected, leaving the mesenteric pedicle with its blood and nerve supply intact. The resultant ends of bowel are anastomosed end-to-end and returned to the abdominal cavity. In the case of the stomach, a section is removed from the greater curvature leaving a branch of the lienal vessel attached, after which the gastric defect is closed. The abdominal incision is closed in layers about the mesenteric pedicle up to the skin. A section of skin corresponding roughly in size to the expected bowel graft is removed. Next the bowel is opened along the antimesenteric border, spread open, and the surface thoroughly cleansed by saline and alcohol. Finally, the bowel is sutured in place forming a flat graft with the mucosal surface outward. After a period of 10 to 12 days the graft is healed (Fig. 1), usually without infection, and ready for subsequent experimentation upon the motility of the intestinal musculature.

Little change may be noted in the surface of the graft for several months. There is perhaps a little more edema and hyperemia than normal. After periods of from four to ten months, depending upon the portion of the tract utilized, certain changes will be definitely established. For the purpose of clarity these will be described separately as early and late changes in the various portions of the graft.

Mucosa.—There is little change in the mucosa in the early stage. It continues to secrete a great deal of mucoid material, similar apparently to the normal secretions. The surface is hyperemic and darker in color than normal. During this period histologic examination demonstrates a beginning destruction of the tips of the villi, a "wearing off," so to speak, whereby they are denuded of mucosal cells (Fig. 2). A mild degree of cellular infiltra-

tion may be noted, but this depends almost entirely upon the amount of surface destruction. These changes, it should be noted, occur earlier in the colon than in other portions of the tract. The junction of the skin and mucous membrane presents a fused unbroken line with no appreciable change in the cells of either (Fig. 3). It is a well defined line with a small amount of granulation tissue and fibrosis.

In the later stages the mucosa takes on a grossly granular appearance (Fig. 4). It bleeds easily to slight trauma and appears to be covered by exudate. This likewise appears first in the colon and stomach preparations, later, if at all, in the small intestinal grafts. The phenomenon appears to be



FIG. 1.—Photograph of a graft from the colon to the abdominal wall three months after operation. Note the traumatized area at one end from application of recording clips. The surface is shiny from secreted mucus.

due in part at least to mechanical irritation by scratching, contact with abrasive surfaces and to drying. Microscopically the mucosa exhibits partial destruction which varies greatly in degree. The milder changes usually seen in the small intestine show surface destruction with exudation which tends to close the openings of the crypts. This produces obstruction of the crypt with cystic dilatation at the base by the products of secretion (Fig. 2). In other more advanced preparations the mucosa may be almost entirely gone and only remnants of epithelium in a mere semblance of the original acinar arrangement remain upon a base of inflammatory granulation tissue (Fig. 5). It is of greatest importance to note the evidence of regeneration in mucosal epithelium especially at the bases of glands. During the process of disintegration one not infrequently sees epithelial budding from the side of a gland (Fig. 6). These budding cells project into the lumen from one side in a manner suggesting small papillomata. They stain more darkly with hematoxylin-eosin than the adjacent cells, and with mucicarmine there is evidence of greater mucoid secretion. Another manifestation of regenera-

tion is seen in areas devoid of epithelium through the agency of severe trauma such as being bitten or chewed. Healing in such an area takes place primarily by granulation tissue which tends to be covered by a thin layer of epithelial cells without, however, the normal acinar arrangement (Fig. 7).

FIG. 2.—High power photomicrograph of an ileal graft five months after operation. Note the superficial destruction and deposition of fibrin. The bases of some of the crypts are dilated by distension with secretory products. The muscularis mucosa is edematous and partly disrupted and moderate cellular infiltration can be seen in the superficial layers.



FIG. 3.—Junction of skin and mucous membrane. The epithelial cells of both structures are fused and a few glandular elements can be seen migrating beneath the skin edge.



Cellular infiltration is more marked in older preparations and again is dependent upon the amount of surface destruction. The cells taking part in this infiltration are chiefly leukocytes. There are also numerous small lymphocytes and wandering cells, some of which demonstrate phagocytic activity.

Another interesting change in the late stages is the frequent extension of squamous epithelium from the skin margin out over the muscosal surface. This appears to take place more readily in a previously traumatized area in which the destruction of epithelium has been partly succeeded by the deposition of a layer of fibrinous exudate. Curiously enough, these epithelial extensions seem to start out first as tiny promontories, but later the tips expand rapidly in all directions so that the final result shows an island of squamous epithelium connected to the natural skin margin only by a narrow pedicle. How far this extension would progress if allowed to go untouched it is impossible to say, since no case has been observed in which a muscosal graft

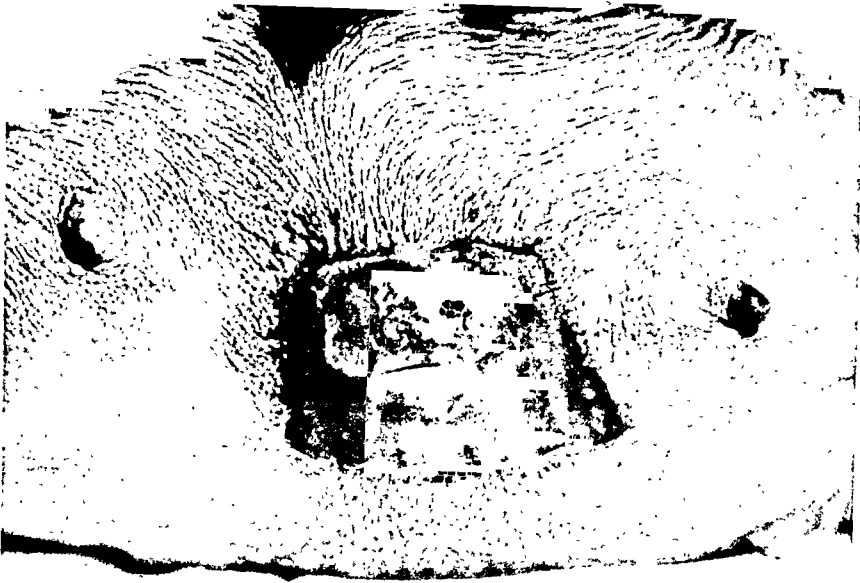


FIG. 4.—Colon graft ten months after operation (same preparation as in Fig. 1). Note the smooth surface with absence of mucosal wrinkles and the granular appearance in places, although mucus is still being secreted.

has been entirely replaced. It seems safe to say, however, that as long as there is actively secreting mucosa present, it will not be covered.

Muscularis Mucosa.—This structure shows no early changes. As the superficial destruction progresses, one notes first a thickening which might indicate a hypertrophy were it not for the splitting apart of some of the fibers by edema which in later stages results in a disruption of continuity almost to the point of total destruction (Fig. 8). This phenomenon may in part answer the question as to the rôle played by this structure in intestinal motility. In spite of the actual destruction of the muscularis mucosa, the intestinal graft *retains its ability to contract following the application of superficial stimuli.*

Cellular invasion attacks this layer in the same manner and type as the mucosa, but only after the latter structure has been partially destroyed.

Submucosa.—The submucosa likewise undergoes an edematous thickening in the early stages which later results in an increased fibrosis. Vascularity

is markedly increased and the vessel walls become thickened. Not infrequently epithelial cells from the mucosa migrate downward through the disrupted muscularis mucosa and form islands in the submucosa which display a characteristic tendency to reform acini (Fig. 8). Such inclusions have

FIG. 5.—High power photomicrograph ten months after operation (same preparation as Fig. 4). There is almost complete absence of mucosal epithelium except for isolated remnants. In the right of the field can be seen a hypertrophied lymph follicle. The submucosa is edematous and the muscularis mucosa is partially disintegrated. This preparation retained an active muscular response to surface stimulation.

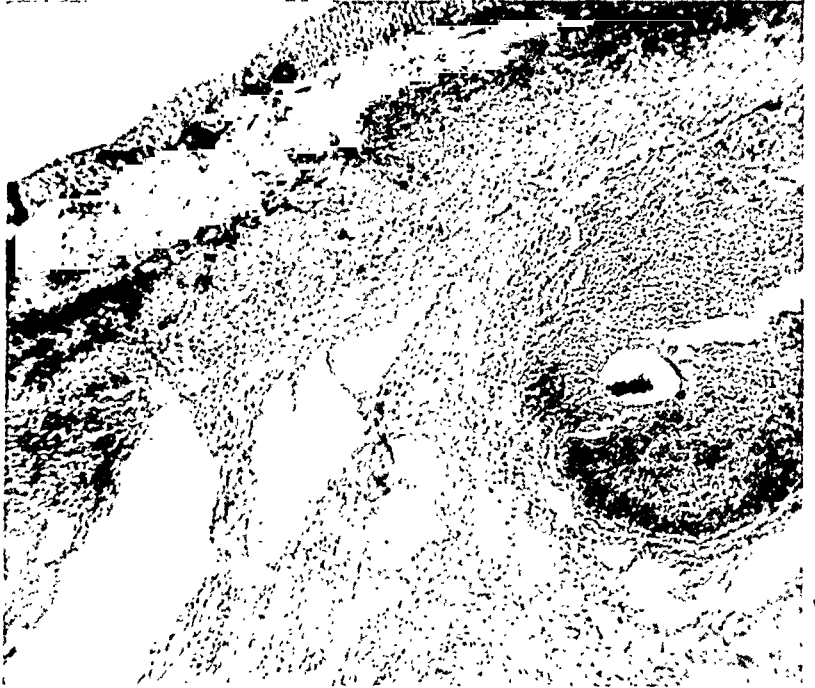


FIG. 6.—Budding within a mucosal gland. In the upper part of the field this has progressed to a true papilloma. In the lower part can be seen the early budding from both sides of a crypt.



been noted in the subcutaneous tissue beneath the skin edge as far as one centimeter from the nearest mucosal border. In the late stages through the process of cellular invasion and advanced fibrosis, the submucosa presents



FIG. 7.—Epithelium growing out over granulation tissue in a defect left from severe trauma. There is a tendency to reproduce acini but as yet they are incompletely formed.



FIG. 8.—Penetration of the muscularis mucosa by the deeper part of the mucosal glands. On the right an island of mucosa has completely penetrated it while at the left can be seen an earlier stage of penetration.

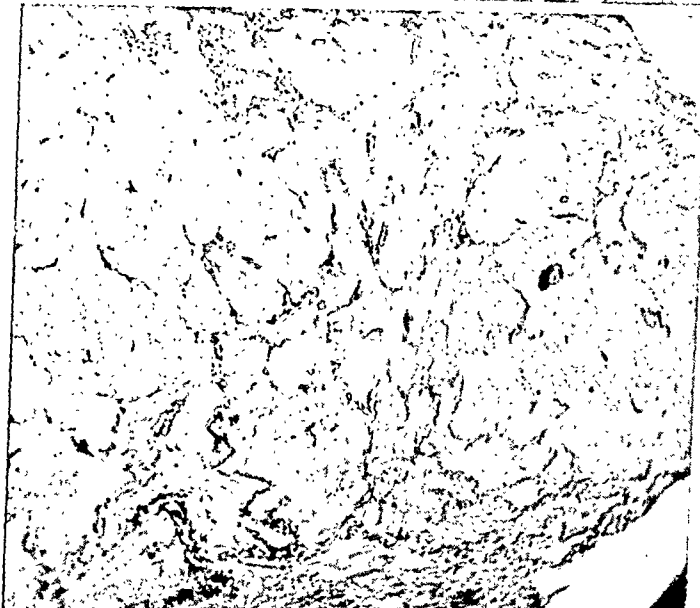


FIG. 9.—Colloid-like accumulation of mucus encapsulated by omentum about an intraperitonealized section of colon. It is surrounded by a single layer of endothelium. This material stains bright red with mucicarmine.

a picture not unlike the base of a chronic ulcer without, however, the destruction of the underlying muscle (Fig. 5).

Muscularis.—This layer exhibits the least changes of all. There is, as a rule, thickening and hypertrophy. Rarely, if ever, is there disintegration or destruction of the muscle bundles although in the late stages moderate cellular invasion may appear. Hypertrophy of the sympathetic ganglia of the plexuses of Meissner and Auerbach has been noted in some instances, but it cannot be said that this is a constant finding.

Section of the mesenteric pedicle apparently does not alter the type of change brought about. A slight dryness of the mucosal surface for a few days after section has been the only difference thus far noted. The development of collateral circulation is usually rapid and sufficient to furnish nourishment to the more delicate intrinsic structures. Possibly this is a factor responsible in part for the questionable ganglion hypertrophy. Certainly it can be said that pedicle section does not destroy the intricate neural mechanism.

PART II.—PERITONEALIZED MUCOSA.—The second group of experiments was designed to demonstrate the effects of peritoneal exposure upon the mucosa. The following procedure was carried out: A transverse V-shaped flap was cut in the antimesenteric portion of the colon of a cat, retracted and tacked down so that the mucosa faced outward. The mucosa was then divided across the base of the triangular flap and the colon defect closed. The preparation was then cleansed thoroughly with saline and alcohol and dropped back into the abdominal cavity. The incision was finally closed in the usual manner.

None of the animals so treated showed any sign of peritoneal irritation following the procedure but after two or three days the abdomens exhibited gradual and apparently painless distension. This was maintained for several days but slowly decreased to normal. Exploratory laparotomy performed during the distended stage revealed quantities of mucus lying free in the peritoneal cavity but no evidence of visceral or parietal inflammation. A later operation after the distension had disappeared showed still active secretion which was apparently being absorbed. Invariably fibrin had collected about the triangular flap and as a rule, omentum was adherent. Biopsy of the mucosal flap three months after the original procedure showed no demonstrable change in the histology of the mucosal cells.

The experiment was then carried out on dogs in a slightly different manner. A section of colon supplied by a single vascular arch was resected, leaving the mesenteric pedicle intact and the continuity of the bowel re-established by end-to-end anastomosis. The resected loop was next opened along the antimesenteric margin and cleaned in the manner previously described. It was everted and the cut margins sewn together around and through the mesentery. The preparation thus formed composed a hollow structure resembling the normal bowel except that the serosa formed the inner lining and the mucosa the outer covering. Finally, the preparation

was dropped back into the abdominal cavity and the incision closed in the usual manner. The same procedure was carried out on different animals using the ileum instead.

Following operation there was no sign of peritoneal irritation at any time but in contrast to the previous group of experiments there was no appreciable distension of the abdomen with mucus. At regular intervals the abdomen was opened, the preparation studied, and a biopsy taken. The results were as follows:

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Twenty-four Days.—The abdominal cavity contained little mucus. The omentum was adherent to the preparation, especially at the lines of suture, but the surface of the mucosa was bright, shiny, and actively secreting. Microscopic study showed no cellular changes whatever. The ileum presented similar findings.

Forty-nine Days.—No free mucus was found in the abdominal cavity but small collections were encapsulated along the mesentery and the omental folds. Microscopic examination showed no structural change in the intestinal wall and healing was complete at the united margins, the muscle being united by fibrous tissue.

Seventy-three Days.—Changes were essentially those noted in the 49 day specimen.

Two Hundred Days.—The pathology was essentially the same as in the previous specimens except for an excess of encapsulated mucus. This had distended the serosa of the omentum and the omental folds until it resembled a cluster of grapes. Histologically, this was not unlike the accumulations found in colloid cancer (Fig. 9). The mucosa continued to secrete actively and no change could be noted in the morphology of the epithelium. The ileal preparation was similar except for the preponderance of mucus in the former.

DISCUSSION.—While perhaps of more academic than practical interest, these experiments have shown that the intestinal mucous membrane is a relatively hardy structure which can not only survive but actually regenerate under unusual and adverse conditions. Mechanical irritation appears to play the major rôle in the changes produced. Infection is warded off by the excellent protection afforded by the secreting mucosa, and rarely if ever does inflammatory change involve the underlying structures until this layer is broken. Such a point may possibly have some bearing upon the relationship between chronic gastritis and peptic ulcer.

The mucosal epithelium exhibits amazing regenerative powers following trauma. This is made possible by the ability of the cells to continue reproduction in spite of the altered environment and the loss of the original nerve and blood supply. Penetration of the muscularis mucosa by epithelial cells clearly demonstrates that this phenomenon does not necessarily indicate malignancy.

The persistence of intestinal muscular activity after partial or complete destruction of the muscularis mucosa proves that this structure is not the chief factor in the production of peristaltic movement as has been supposed by some investigators. The slight diminution of muscular response often noted in old preparations can be easily explained on the basis of diminished stimulus receptivity.

As for the practical application of these experiments, mention has already been made of the studies in intestinal motility made possible, thereby opening up a new field in the study of intestinal physiology. Moreover, in keeping with the recent advances in the transplantation of tissues, it has been shown the intestinal mucosa can be successfully transplanted to other portions of the body. Such a procedure can possibly be employed in the replacement of mucosa elsewhere in the body which has been destroyed through the agency of trauma or malignant growth.

CONCLUSIONS

Transplantation of gastro-intestinal segments to the abdominal wall has shown that the structure can remain viable and actively motile for indefinite periods of time, despite the severance of the natural nerve and blood supply, if a sufficient length of time has elapsed to allow collateral circulation to develop.

The pathologic changes involving the transplanted tissues are respectively, gradual destruction of the mucosa with cellular infiltration but a persistent secretory capacity and a characteristic regenerative power; partial destruction of the muscularis mucosa with penetration by migrating epithelial buds; edema and fibrosis of the submucosa with hypertrophy and hyperplasia of the smaller arterioles; and finally questionable hypertrophy of the lymphoid follicles and sympathetic ganglia.

Exposure of the mucosa to the peritoneum produces no apparent histologic change in the former, nor is the secretory activity inhibited. Accumulated mucus is enveloped by fibrin and omentum producing a structure not unlike the jelly-like collections of mucus in colloid cancer.

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SOLID TUMORS OF THE MESENTERY

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SOLID tumors of the mesentery are noted infrequently. A comprehensive review of the literature discloses 186 reported cases. Cystic tumors of the mesentery are more common, the ratio being about two to one. The rarity of the condition prompts the following case report together with a brief summary of all recorded cases for the past 15 years.

CASE REPORT

J. M., a male, 46 years of age, a native of Poland, was admitted to the Alexian Brothers Hospital March 27, 1931, for an abdominal operation. He had been a resident of Chicago for the previous 23 years. A large swelling was discovered accidentally in the lower part of his abdomen. It was with difficulty that he was convinced that there was anything unusual about his abdomen since he firmly maintained that he had been unaware of the presence of the swelling and that he had never been ill a day in so far as he could remember. There had been no recent gain nor loss in weight; digestive and urinary disturbances, bleeding from the bowels, and acute abdominal attacks were denied. There was no history of injuries or previous operations. The family history was negative.

Physical Examination.—Temperature, 98° F.; pulse, 72; respiration, 18; blood pressure, 138/82. He was 66½ inches tall and weighed 138 pounds. The build was stocky; he had a ruddy complexion and was well nourished. There were no palpable lymph nodes. The abdomen presented a uniform enlargement in its lower two-thirds about equaling that produced by a seven months pregnant uterus. The outlines of this mass were readily determined. It was not sensitive; the overlying wall was tense and thinned. It was situated for the greater part in the lower half of the abdomen with one-third of its volume to the left of the midline and with the remainder to the right. The lower limit was just above the symphysis while the upper limit lay two fingerbreadths above the umbilicus. Over the lower pole a firm nodule was palpated which appeared to be attached to the larger mass. The entire mass could be slightly moved from side to side. It could not, however, be moved in an upward and downward direction. The impression was given to the palpating hands that it was more or less firmly fixed. It did not move with respiration. Percussion over the tumor elicited a dull note. There was no shifting dullness in either flank. The liver and spleen were not palpable.

Red blood cells, 3,970,000; hemoglobin, 75 per cent; white blood cells, 6,500; differential count: polymorphonuclears, 69; small lymphocytes, 29; eosinophiles, 1; transitionals, 1. The Wassermann and Kahn tests were negative, a plain roentgenogram of the chest was negative. Another made of the abdomen showed the outline of the lower poles of the kidneys to be normal in size and in position. Gastro-intestinal series (barium meal); there was no delay in the emptying time of the stomach or of the small intestine. No deformities were seen. A large shadow persisted on all the films of the abdomen with the ascending colon to the right and the transverse colon above. The transverse colon appeared to be resting on top of the mass and did not present its normal downward convexity (Fig. 1). The small intestine was crowded upward and to the left. The pre-operative diagnosis was mesenteric tumor.

Operation.—March 31, 1931. Ethylene and ether anesthesia. The abdomen was opened

through a right paramedian incision. A large bluish-gray tumor presented which practically filled the abdomen. (Fig. 2.) No free fluid was present. There were no masses in the omentum and no nodules could be palpated in the liver. No enlarged lymph nodes could be palpated in the root of the mesentery. The liver and spleen were not enlarged. There were remarkably few adhesions between the mass and the surrounding structures. Passing across the mass upward and to the left was a loop of ileum about 18 inches in length, the mesentery of which was a part of that in which the tumor was located. The blood supply of this loop passed directly through the mass and was incorporated in it. Equal parts of the tumor lay to either side of this segment of mesentery so that it was impossible to separate the two without destroying the blood vessels supplying this part of the small intestine. The involved segment of bowel was in the lower ileum. The tumor had partly undergone cystic degeneration. It was impossible to deliver it from the abdomen because it was firmly held in the root of the mesentery. Four hundred fifty cc. of serosanguineous fluid were aspirated from the mass. The opening made by the trocar was immediately closed, and the partly collapsed structure was drawn into



FIG. 1.—Showing the transverse colon above and apparently being supported by the mass below.



FIG. 2.—The growth removed with the mesentery and attached segment of ileum.

the abdominal incision. Two points six inches above and below the involved ileum were selected and a lateral anastomosis was made. The intestine was divided and the detached segment of ileum together with the adjacent mesentery and the tumor were then removed in one mass. Recovery was uneventful and the patient was discharged from the hospital April 20.

Pathologic Report.—Macroscopic—A bluish-gray tumor intimately associated with the mesentery with an attached segment of small intestine 25 inches in length. The tumor was 21 inches in its greatest circumference and weighed 5½ lbs. On its lower pole were three nodules. The largest of these was the size of a goose egg. It was cystic with firm thick walls. The other two were solid. The center of the principal mass was necrotic and contained a bloody fluid with a thick deposit of broken down tissue. The inner surfaces of the cavity were irregular and friable. The wall varied in thickness from 1 to 4½ cm. The cut surface was of varying consistency. There were soft areas not greatly differing in appearance from that of the white matter of the brain, while others were firm and leathery.

Microscopic (Dr. R. H. Jaffé)—The wall of the cystic cavity shows three different layers. The outer layer is composed of dense fibrillar connective tissue with small peri-vascular round cell infiltration. The middle layer which is sharply separated from the

outer layer is made up of polymorphous cells in a vascular tissue. Large spindle cells with oval nuclei containing numerous small chromatin granules are predominating. They are arranged in different directions and are separated by a small amount of collagenous ground substance. Between these cells are single very large elements with huge irregular nuclei. They are the transition stages between the huge cells and the smaller spindle cells. Scattered loosely between the cells previously described are found small round cells and a few eosinophilic leukocytes. Mitotic figures are quite numerous and show short and clumpy chromosomes. The cellular zone passes into the innermost zone which is formed by diffusely necrotic tissue. Between the necrotic masses are erythrocytes. Diagnosis, fibrosarcoma of the mesentery with central liquefaction.

Postoperative Course.—The patient was examined May 5, 1932, at which time he weighed 12 pounds more than before operation. He was free of symptoms. He entered St. Mary's Hospital July 7, 1935, complaining of swelling of the abdomen and the lower extremities, and died two days later. Autopsy showed general abdominal metastases diagnosed as spindle cell sarcoma.

The first survey of solid tumors of the mesentery was made by Harris and Herzog,¹ who reviewed the literature previous to 1897 and tabulated 56 reported cases in addition to one of their own. In 1920, Bigelow and Forman² reported a case and found some 100 cases recorded up to that time. The present survey discloses an additional 86 cases reported since 1920, thus bringing the total to approximately 186 cases.

In a report by Rankin and Major,³ from the Mayo Clinic, the rarity of occurrence of these tumors is emphasized by the fact that only 22 were found among 820,000 patients admitted. Solid tumors of the mesentery are about evenly distributed between the sexes. In the cases reviewed there were 42 in the male, and 46 in the female. The age varies between 1 and 85 years.

The origin of mesenteric new growths is as effectively shrouded in mystery as is the etiology of tumors and cysts elsewhere. Rankin and Major³ expressed the opinion that a certain number of them depend for their origin on congenital defects in the development of the mesentery. These authors discourse at some length upon the embryology of the mesentery and its morphologic relationship to neighboring structures. Trauma or previous diseases as etiologic agents were singularly lacking in all of the cases.

It is of interest to note the great variety of tissues found in tumors of the mesentery. It is small wonder, then, that pathologists find it difficult to agree as to the true nature of such diverse structures. The sections of the case here reported were shown to pathologists who did not agree to the diagnosis as given. One described the histopathology without giving a definite diagnosis. Similarly in several of the recorded cases the histopathology was given without statement of diagnosis. This is not surprising when one considers the structure of the mesentery. It is primarily a sheet of mesenchyme covered on both sides with mesothelium or endothelium, and from the mesenchyme there are derived all the fibrous connective tissues of the body. Running throughout this complex structure are nerve fibers, blood and lymph vessels and lymph nodes, any one of which may become the site of development of neoplastic formation.

Rawls⁴ included the following tumors among the solid neoplasms of the mesentery: Lipoma, fibroma, carcinoma, and sarcoma. Bowers⁵ states that of the solid tumors of the mesentery lipomata are the commonest, and fibromata the rarest. Among the total cases reported since 1920 the type and frequency are as follows: Lipoma, 12 cases; fibroma, 26 cases; sarcoma, 35 cases; cavernous hemangioma, 2 cases; teratoblastoma, 2 cases; lymphangioma, 1 case; lymphoma, 1 case; myxoma, 1 case; amyloid tumor, 1 case; osteosarcoma, 1 case; neuroma, 1 case; undesignated type, 2 cases; mixed mesodermal, 1 case.

The site of sarcomatous mesenteric tumors is, according to Szenes,⁶ the mesentery of the small intestine in two-thirds of all cases. Murphy states that sarcomata show an especial predilection for the radix mesenterii, while the fibromata are generally found at the mesenteric attachment near the intestine. The greatest number have been described as occurring in the mesentery of the terminal portion of the ileum. However, cases are reported in which they have been found in the mesentery of the jejunum, the cecum, the appendix, and in all parts of the mesenteric coli. In one case the tumor occurred in such close relationship with the stomach that a resection of the stomach was done under the impression that it was a cancer of the stomach.

The cases may be divided into two groups with respect to symptoms: First, those cases which present few if any symptoms. The symptoms are here dependent on the size, the location, and the mobility of the growth. Even a large, slow growing tumor firmly held in the root of the mesentery may produce few symptoms. The few that are complained of may be due simply to the mechanical effects of the growth; *e.g.*, pressure, crowding, *etc.* Upon examining such a case a tumor may or may not be palpable. In the second group of cases there are rather frank abdominal symptoms varying in intensity from indigestion, dyspepsia, epigastric distress, general abdominal distress, gaseous distension, fulness, belching, constipation or diarrhea, loss of weight, and indefinite abdominal pains, to a sudden and acute abdominal attack, rapidly developing to the stage of the acute surgical abdomen. In this group are often met cases of acute intestinal obstruction; for instance, volvulus, intussusception, *etc.* One case of sarcoma of the mesentery is reported in which the patient was seized with a sudden acute abdominal attack requiring operation, and it was then discovered that there had occurred a severe hemorrhage into the peritoneal cavity from a ruptured blood vessel in the sarcomatous mass. Another case is reported in which the tumor ruptured, freeing intestinal contents into the peritoneal cavity, resulting in peritonitis. Often cases in this group come to operation with the mistaken diagnosis of acute appendicitis with or without abscess formation. This is readily understood since many of the tumors occur in the region of the terminal ileum.

The following case⁷ illustrates the latency of the symptoms that are sometimes seen in the cases of Group 1: A patient presented himself for the removal of a sebaceous cyst in the abdominal wall. A tumor was discovered the size of a child's head in the right iliac fossa of which the patient had

TABLE I
SUMMARY OF CASES REPORTED DURING THE PAST FIFTEEN YEARS

Author	Where Recorded	History	Preoperative Diagnosis	Treatment	Postoperative Diagnosis	Result
Ransohoff, Louis J., and Friedlander, A. Niosi, F.	ANNALS OF SURGERY, vol. 73, p. 211, February, 1921 Archiv. ital. di chir., Bologna, vol. 3, p. 657, July, 1921	Male, 73 yrs. of age. Palpable tumor Young woman. Acute abdominal attack	None Ileus	Resection Resection	Fibrosarcoma of mesosigmoid Fibroma of the mesentery of the small intestine	Recovery Recovery
Alton, B. H.	Boston Med. and Surg. Jour., vol. 185, p. 205, August 18, 1921	Female, aged 60 yrs. Constipation and increasing abdominal distress	Mesenteric	No attempt made to remove because of extensive involvement	Biopsy, lipoma huge size	Recovery
Kyle, H. G.	Brit. Jour. Surg., vol. 9, p. 295, October, 1921	Male, 40 yrs. of age. Abdominal pain and increasing constipation	Mesenteric tumor	Resection	Fibroma of the mesentery of ileum	Recovery
Ecoffey, M.	Schweiz. med. Wchnschr., vol. 52, p. 202, February 23, 1922	Female, 85 yrs. of age. Dropsy. Arteriosclerosis, myocardial degeneration	None	None	None	Autopsy, found 2 amyloid tumors in the mesentery
Cartolari, E.	Gazz. d. osp., vol. 43, p. 271, March 19, 1922	Male, aged 28 yrs. Digestive disturbances	Primary tumor of mesentery	Tumor enucleated without resection	Sarcoma of mesentery near its origin	Recovery
Bell, George, and Inglis, K.	Med. Jour. Australia, vol. 1, p. 375, April 7, 1923	Male, 25 yrs. of age. Noticed a swelling in the abdomen for three weeks. Rapid growth	Retropertitoneal tumor	Resection of 93½ in. of ileum, cecum, ascending colon, and part of transverse colon	Spindle cell fibrosarcoma. Lower end of ileum	Recovery
Schmid, H. H.	Arch. f. Gynäk., vol. 118, p. 490, May, 1923	Female, aged 55 yrs. Palpable tumor in lower abdomen	Fibroma of uterus	Enucleation of the tumor without resection	Spindle cell sarcoma of the transverse mesocolon	Recovery
Avoni, A.	Arch. ital. di chir., vol. 7, p. 360, July, 1923	Male, aged 30 yrs. Abdominal distress. Pain in right hypochondrium	Cyst of mesocolon	Enucleation of tumor without resection	Round cell sarcoma of mesocolon. Size of fetal head	Recovery
Waser, B.	Schweiz. med. Wchnschr., vol. 53, p. 755, August 9, 1923	Female, 55 yrs. of age. Loss of appetite, loss of weight past 2 yrs.	None	Resection	Fibrosarcoma, size of child's head. Lower end of ileum	Died
Rawls, Julian L.	Virginia Med. Month., vol. 50, p. 764, February, 1924	Negress, aged 21 yrs. Pain in lower abdomen, bilateral. Palpable abdominal mass in midline	Malignancy of right ovary	Resection	Fibroma of the mesentery of lower end of the ileum	Recovery
Nossen, H.	Beitr. z. klin. Chir., vol. 132, p. 551, 1924	Female, 38 yrs. of age. Abdominal tumor discovered by her physician	None	Resection	Spindle cell sarcoma of mesentery of ileum. Size of child's head	Died fifth post-operative day

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Nossen, H.	<i>Ibid.</i>	Male, 58 yrs. of age. Pelvic tumor	None	Resection	Spindle cell sarcoma of the mesocolon. Size of child's head	Not stated
Nossen, H.	<i>Ibid.</i>	Male, aged 62 yrs. Intestinal and nutritional disturbance of years' duration. Abdominal tumor	Mesenteric tumor	Resection	Fibrosarcoma of mesentery of ileum. Size of fetal head	Recovery
Nossen, H.	<i>Ibid.</i>	Male, 23 yrs. of age. Abdominal pain and epigastric distress. Abdominal tumor in umbilical region	None	Resection	Round cell sarcoma of the mesentery of the ileum, size of two fists	Recovery
MacAuley, Chas.	Irish Jour. Med. Sc., p. 54, February, 1925	Female, 20 yrs. of age. Vague abdominal discomfort with intermittent vomiting. Palpable abdominal tumor	Inflamed ovarian cyst	Resection	Fibroma of mesentery of lower end of ileum. Size of two fists	Recovery
deCourcy, J. L., and Maloney, J. J.	Surg., Gynec., and Obst., vol. 40, p. 402, March, 1925	Female, 25 yrs. of age. Pain and swelling in the right side of the abdomen	None	Resection	Fibroma of the mesentery of the ileum	Not stated
deElizalde, P. I., and Medeiros, J.	Semana med., vol. 1, p. 1405, June 25, 1925	Infant, 12 mos. of age. Abdominal tumor discovered at examination	None	Exploratory operation	Sarcoma of the mesentery of the ileum	Died at operation
Nigrisoli, P.	Arch. ital. di chir., vol. 13, p. 170, 1925	Female, aged 30 yrs. Epigastric pain, loss of strength, swelling in left flank for one month	None stated	Exploratory operation, impossible to remove the tumor because of adhesions. Biopsy	Blastoma of mesentery of the lower end of the ileum	Died five days later
Wassertrüding, O.	Arch. f. klin. Chir., vol. 137, p. 456, 1925	Male, aged 47 yrs. Acute abdominal attack. Palpable tumor, size of child's head, beneath right costal border	Acute cholecystitis, or atypical appendiceal abscess	Enucleation without resection	Fibromyoma of the mesentery of the jejunum	Died one week later of pulmonary embolism
Cannon, D. J., and O'Kelly, W. D.	Irish Jour. Med. Sc., p. 571, December, 1925	Male, 3 yrs. of age. Palpable tumor in abdomen	Mixed tumor of right kidney	Resection	Teratoblastoma of the mesentery of the lower end of the ileum	Recovery
Schürer-Waldheim, F.	Arch. f. klin. Chir., vol. 140, p. 601, 1926	Female, aged 44 yrs. Abdominal tumor, loss of appetite. Duration 1 yr.	Omental or mesenteric tumor	Operation. What was done not stated	Cystic sarcoma, size of fist, in mesenterial radix of ileum	Recovery
Piccinelli, A.	Policlinico, vol. 33. (sez. chir.), p. 322, June, 1926	Female, aged 2 yrs. Abdominal symptoms for 2 mos.	Abdominal tumor, tuberculoma, intussusception	Enucleation	Mixed mesodermal tumor, mesentery lower end of ileum	Died 24 hrs. after operation
Braunck, H.	Deutsche Ztschr. f. Chir., vol. 195, p. 345, 1926	Male, aged 27 yrs. Recently discovered a rapidly growing tumor in the umbilical region	None stated	Enucleation	Fibroma of mesentery of lower end of ileum. Size of fist	Recovery

TABLE I (Continued)

Author	Where Recorded	History	Preoperative Diagnosis	Treatment	Postoperative Diagnosis	Result
Gey, R.	Deutsche Ztschr. f. Chir., vol. 199, p. 341, 1926	Male, 68 yrs. of age. Acute abdominal attack. Tenderness in lower right quadrant	Acute appendicitis	Resection	Fibroma, mesentery lower end of ileum	Recovery
Mirer, W. J.	Arch. f. klin. Chir., vol. 143, p. 710, 1926	Male, 44 yrs. of age. Abdominal pains, blood colored vomitus, intestinal obstruction	Perforated ulcer; intestinal obstruction	Resection	Lipoma of lower end of ileum in its mesentery. Volvulus due to the tumor	Died 15 hrs. later
Baldwin, J. F.	Am. Jour. Surg., vol. 2, p. 160, February, 1927	Female, 24 yrs. of age. Operated elsewhere 1925. Diagnosis: Malignant retroperitoneal tumor. Merely closed abdomen. Later the recorder operated and discovered the true nature of the case	Retroperitoneal fibroma	Resection of 6 ft. of small intestine. Anastomosis using the Murphy button	Huge fibroma of the mesentery of the jejunum. Weight: 25 lbs.	Recovery
Bovin, Emil	Acta obst. et gynec. Scandinav., vol. 6, p. 135, 1927	Female, aged 29 yrs. Abdominal tumor, freely movable from side to side	Pedunculated myoma of uterus, or solid tumor of ovary	Enucleation	Fibromyoma, size of a child's head, in the mesocolon of the transverse and descending colon	Recovery
Polacco, E.	Beitr. z. klin. Chir., vol. 141, p. 102, 1927	Female, 26 yrs. of age. No symptoms. Palpable mass in the abdomen	None	Extirpated mass without resection of intestine	Neuroma racemosum in the great omentum and in the mesenteric radix	Recovery
Darnall, W. E.	ANNALS OF SURGERY, vol. 87, p. 870, June, 1928	Female, 25 yrs. of age. Tumor mass in the abdomen	None	Resection	Fibromata in the mesentery of the ileum	Died 9 hrs. post-operative
Bigelow, L. L., Scott, E., and Obenour, S. W.	ANNALS OF SURGERY, vol. 87, p. 879, June, 1928	Female, aged 8 yrs. Markedly distended abdomen	Tuberculous peritonitis	Exploratory laparotomy. Metastases in the liver, and entire mesentery filled with metastatic nodes	Lymphosarcoma of the mesentery of the lower end of ileum	Death 1 hr. post-operative
Sokolow, N. N.	Deutsche Ztschr. f. Chir., vol. 210, p. 397, 1928	Male, aged 12 yrs. Epigastric pains and an abdominal tumor for 2½ mos.	Tumor of great omentum	Resection of the sigmoid	Fibroma of the mesosigmoid	Recovery
Grigorowsky, J. M.	Deutsche Ztschr. f. Chir., vol. 210, p. 390, 1928	Male, aged 19 yrs. For three months the patient had been aware of the presence of an abdominal tumor	Mesenteric tumor	Resection	Fibroma of the mesentery of the lower ileum, size of fetal head	Recovery
Cappellani, S.	La Clin. ostet., vol. 30, p. 576, August, 1928	Female, 57 yrs. No symptoms. Palpable tumor in the left side of the abdomen	Solid tumor of the left ovary	Enucleation without resection	Fibrosarcoma of the mesocolon	Recovery

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Schmitt, W.	Zentralbl. f. Gynäk., vol. 53, p. 719, March 23, 1929	Female, aged 21 yrs. Palpable tumor, size of fetal head, on the left side of the abdomen	None	Resection	Cavernous hemangioma of the mesosigmoid	Recovery
Frank, Louis	Kentucky Med. Jour., vol. 27, p. 169, April, 1929	Male, aged 28 yrs. Abdominal tumor for 12 yrs. Sudden acute abdominal attack	Appendicitis, with peri-appendiceal abscess. Intestinal obstruction	Resection	Mesenteric tumor of the lower ileum (histologic variety not stated)	Recovery
Courty, L., and Falala, C.	J. de chir., Par., vol. 33, p. 473, April, 1929	Male, 44 yrs. of age. Came in to have a sebaceous cyst removed from the abdominal wall. His physician discovered a large abdominal tumor which patient did not know existed	None	Resection	Fibroma of the mesentery of the lower ileum	Recovery
Tourneux, J. P.	Presse med., vol. 37, p. 593, May 4, 1929	Male, 48 yrs. of age. Palpable tumor and movable. Recurrent abdominal pain	Tumor of mesentery	Enucleation	Fibroma of mesentery	Recovery
Fisher, W. H.	Am. Jour. Surg., vol. 7, p. 803, December, 1929	Female, aged 37 yrs. Backache and radiating pains, 2 yrs. duration. Solid mass in vault of vagina	Retroperitoneal growth	Enucleation	Encapsulated mesenteric fibromyoma in the pelvic mesocolon	Recovery
Ramselaar, C. G.	Nederl. tijdschr. v. geneesk., vol. 74, p. 2392, May 10, 1930	Male, 52 yrs. of age. Acute retention of urine. Palpable abdominal tumor	Tumor of the small intestine of unknown origin	Resection	Fibrosarcoma of the mesentery of the lower ileum, tumor was necrotic	Recovery
Crane, Whitfield	Am. Jour. Surg., vol. 9, p. 441, September, 1930	Female, aged 39 yrs. Intermittent dull pain in the lower abdomen for past six months	Abdominal tumor	Enucleation without resection	Lymphangioma of the mesentery of the lower ileum	Recovery
Matthaes	Deutsche Ztschr. f. Chir., vol. 224, p. 98, 1930	Male, 22 yrs. of age. Acute abdominal crisis	Perforated abdominal viscus, with peritonitis	Resection	Sarcoma of the mesentery of the lower ileum	Died of postoperative pneumonia
Antoine, T.	Arch. f. klin. Chir., vol. 160, p. 458, 1930	Female, 24 yrs. of age. Pregnant 7 mos. "Yellow vomitus" and abdominal pain for past 8 mos.	Ovarian tumor, or pedunculated fibroid with twisted pedicle	Resection	Fibroma of the mesentery of the lower ileum. Gangrenous bowel	Recovered from the operation; premature labor, delivered, died 1 hr. later
Masumoto, K.	Tr. Jap. Path. Soc., vol. 21, pp. 844-845, 1931	Female, aged 57 yrs. Palpable tumor. Colic-like pains throughout abdomen. Vomiting	Movable tumor	Exploratory	Spindle cell sarcoma in mesentery of jejunum	Died
Masumoto, K.	- <i>Ibid.</i>	Female, aged 51 yrs. Pain and swelling in abdomen for one year. Slow growing tumor	Tumor of lymph nodes	Exploratory. Biopsy	Spindle cell sarcoma in mesentery of small intestine	Died

TABLE I (Continued)

Author	Where Recorded	History	Preoperative Diagnosis	Treatment	Postoperative Diagnosis	Result
Simoës Trincão, M.	Med. contemp., vol. 49, p. 73, March 1, 1931	Female, aged 60 yrs. Severe pain in the upper abdomen, palpable abdominal tumor, ascites, diarrhea	Tumor of the alimentary tract	Paracentesis to relieve the ascites, otherwise symptomatic only	Sarcoma in the transverse mesocolon	Postmortem examination
Vozza, F.	Ann. di ostet. e ginec., vol. 53, p. 501, May 31, 1931	Female, aged 34 yrs. Fulness and distention of the lower left quadrant for 2 mos., abdominal swelling for 10 yrs. Pregnant	Dermoid cyst	Enucleation	Neurolipoma, the size of an orange, in the mesocolon of the descending colon	Recovery
Bergareche, J.	Arch. de med., cir. y especialid., vol. 34, p. 1017, November 7, 1931	Male, aged 42 yrs. Movable tumor in the abdomen for 6 mos., increasing size of abdomen	Mesenteric tumor	Resection	Fibrosarcoma in the mesentery of the small intestine	Recovery
Martínez, M.	Bol. Soc. de cir., Chile, vol. 10, p. 10, April 13, 1932	Female, aged 42 yrs. Gradual enlargement of abdomen for 4 yrs. Vomiting and continuous pain	Hydatid cyst of mesentery	Enucleation	Lipoma of descending mesocolon	Recovery
Pelliccia, G.	Ann. ital. di chir., vol. 11, p. 949, August 31, 1932	Female, aged 26 yrs. Dull pain in both loins for 2 mos., loss of weight. Acute abdominal attack	Acute appendicitis	Enucleation	Fibrolipoma of the mesentery of the terminal ileum	Recovery
Judd, E. S., and Crisp, N. W.	Proc. Staff Meet., Mayo Clinic, vol. 7, p. 555, September 21, 1932	Female, aged 53 yrs. Fulness in lower abdomen for 6 mos. Worse when lying down	Mesenteric tumor	Enucleation	Fibroma in mesentery of jejunum	Cured
Summers, J. E.	Surg., Gynec. and Obst., vol. 55, p. 244, August, 1932	Female, aged 3 yrs. Mother discovered movable tumor in abdomen one month before examination by physician	Mesenteric tumor	Enucleation	Fibroma in mesentery of jejunum	Recovery
McCalla, L. H.	Jour. South Carolina Med. Assn., vol. 28, p. 211, August, 1932	Female, aged 70 yrs. Mass in lower abdomen	Pelvic malignancy	Resection	Fibroma in mesentery of lower ileum	Recovery
Counseller, V. S., and Cox, F. W.	Surg. Clin. N. Amer., vol. 12, p. 1033, August, 1932	Female, aged 34 yrs. Swelling in abdomen for 2 mos.	Pedunculated fibroma	Resection	Fibroma in the leaves of the mesentery at the junction of jejunum and ileum	Recovery
Pintos, C. M., and Murtagh, J. J.	Semana med., vol. 2, p. 1531, November 24, 1932	Female, aged 2½ yrs. Rapidly growing abdominal tumor for 2 mos., jaundice	Hydatid cyst, tuberculous peritonitis, neoplasm	Symptomatic only	Lymphosarcoma in the mesocolon with metastasis	Postmortem examination

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Rankin, F. W., and Major, S. G.	Surg., Gynec., and Obst., vol. 54, p. 809, May, 1932	Female, aged 57 yrs. Swell- ing in abdomen 2 mos. dura- tion. Palpable mass	Not stated	Not stated	Lipoma in mesentery 6 ft. from duodenojejunal junc- tion	Not stated
Rankin, F. W., and Major, S. G.	<i>Ibid.</i>	Female, aged 28 yrs. Palpa- ble mass in abdomen for 6 mos.	Not stated	Not stated	Lipoma in mesentery of small intestine	Not stated
Rankin, F. W., and Major, S. G.	<i>Ibid.</i>	Female, aged 38 yrs. Pain in lower abdomen for 2 mos.	Not stated	Not stated	Lipoma in mesosigmoid	Not stated
Rankin, F. W., and Major, S. G.	<i>Ibid.</i>	Male, aged 46 yrs. Pain in upper abdomen for several years. Palpable tumor for 2 mos.	Not stated	Not stated	Multiple fatty tumors of mesentery of small intestine	Not stated
Rankin, F. W., and Major, S. G.	<i>Ibid.</i>	Female, aged 46 yrs. Abdom- inal distress for 6 mos.	Not stated	Not stated	Lipoma in mesentery of up- per part of small intestine	Not stated
Rankin, F. W., and Major, S. G.	<i>Ibid.</i>	Female, aged 25 yrs. Dull intermittent pain in abdo- men. Palpable mass in ab- domen for 18 mos.	Not stated	Resection	Fibroma in mesentery of small intestine	Not stated
Rankin, F. W., and Major, S. G.	<i>Ibid.</i>	Male, aged 50 yrs.	Not stated	Not stated	Fibroma in mesentery of small intestine	Not stated
Rankin, F. W., and Major, S. G.	<i>Ibid.</i>	Male, aged 45 yrs. Palpable mass. Pain in lower abdo- men for 4 mos.	Not stated	Resection	Fibrosarcoma in mesen- tery of small intestine	Recovery
Rankin, F. W., and Major, S. G.	<i>Ibid.</i>	Female, aged 68 yrs. Distress in lower abdomen for 3 yrs.	Not stated	Enucleation	Fibromyosarcoma in mes- entery of small intestine	Not stated
Rankin, F. W., and Major, S. G.	<i>Ibid.</i>	Male, aged 54 yrs. Loss of weight. Epigastric distress for 6 wks.	Not stated	Inoperable. Biopsy. Palliative intestinal anastomosis	Fibrosarcoma of mesentery	Not stated
Rankin, F. W., and Major, S. G.	<i>Ibid.</i>	Male, aged 44 yrs. Loss of weight. Abdominal distress for 8 mos.	Not stated	Not stated	Fibrosarcoma in mesentery of small intestine	Not stated
Rankin, F. W., and Major, S. G.	<i>Ibid.</i>	Male, aged 40 yrs. Loss of weight. Shooting pains in lower abdomen for 18 mos.	Not stated	Not stated	Low grade myxoma in mes- entery of jejunum	Not stated
Rankin, F. W., and Major, S. G.	<i>Ibid.</i>	Male, aged 53 yrs. Loss of strength, constipation, bloody stools, soreness in lower ab- domen for one year	Not stated	Enucleation	Spindle cell sarcoma in mes- entery of ileum	Returned 6 yrs. later with metas- tasis of the liver
Rankin, F. W., and Major, S. G.	<i>Ibid.</i>	Male, aged 56 yrs. Dull lower abdominal pain. Three attacks of colic in past 5 years. Acute abdomen developed. Emergency operation	Not stated	Not stated	Multiple degeneration of sarcomatous cyst in mesen- tery of small intestine. Ruptured with peritonitis	Died 6 days after operation

TABLE I (Continued)

Author	Where Recorded	History	Preoperative Diagnosis	Treatment	Postoperative Diagnosis	Result
Rankin, F. W., and Major, S. G.	Surg., Gynec., and Obst., vol. 54, p. 809, May, 1932	Male, aged 60 yrs. Increasing constipation, 2 yrs. loss of weight	Not stated	Inoperable. Biopsy	Very malignant myxosarcoma in mesentery of small intestine	Not stated
Ambrumyants, G. N.	Sovet. khir., vol. 4, p. 610, 1933	Male, 5 yrs. of age, slowly enlarging tumor since birth, daily vomiting	Intraperitoneal tumor	Resection of 12 ft. of the small intestine	Diffuse cavernous hemangioma in the mesentery of the small intestine	Died 5 mos. later of continuous diarrhea
d'Abreu, F.	Brit. Jour. Surg., vol. 21, p. 212, October, 1933	Female, aged 22 yrs. Acute abdominal attack	Acute appendicitis	Resection. End-to-end anastomosis	Lipoma in mesentery of small intestine	Recovery
Montemartini, G.	Gazz. internaz. med.-chir., vol. 41, p. 584, October 15, 1933	Male, aged 30 yrs. Diffuse pain in abdomen for 1½ mos. Palpable tumor	Mesenteric neoplasm	Enucleation	Spindle sarcoma of the omentum	Recovery
Gruhn, G.	Folia haemat., vol. 49, p. 268, 1933	Male, aged 64 yrs. Palpable tumor in upper abdomen, left side. Clinical picture of polycythemia	Not stated	Symptomatic only	Sarcoma of the mesocolon	Died, postmortem examination
Diaz, F., and Rivero, L.	Gac. med. de Caracas, vol. 40, p. 357, December 31, 1933	Female, aged 24 yrs. Rapidly growing tumor in abdomen for 2 mos.	Malignancy of ovary	Resection	Malignant tumor (variety not stated) of the mesentery of the ileum	Recovery
Bordeianu, I.	Rev. de chir. Bucuresti, vol. 36, p. 262, July-August, 1933	Male, aged 65 yrs. Abdominal pain for several months. Sudden acute attack of intestinal obstruction	Acute intestinal obstruction	Emergency laparotomy, tumor enucleated	Fibrosarcoma in the mesocolon	Died 5 hrs. later
Grapiolo, A. C., and Palazzo, R.	Rev. sud-am. de endocrinol., vol. 16, p. 627, August 15, 1933	Male, middle aged. Pain in the liver region, abdominal distention. Acute lung symptoms. Pleural effusion	Not stated	Symptomatic only	Lymphosarcoma of the mesentery in the region of the pancreas, highly malignant	Died, postmortem examination
Perrardo G.	Arch. ital. d. mal. d. app. diger., vol. 2, p. 415, October, 1933	Male, aged 50 yrs. Pain in the epigastric region for 10 yrs.	Retroperitoneal tumor	Resection	Myxosarcoma in the mesocolon of the transverse colon	Death from metastasis 11 mos. later
Weaver, O. H.	Jour. Med. Assn. Georgia, vol. 22, p. 295, August, 1933	Negro. Female, aged 10 yrs. Swelling in abdomen	Mesenteric tumor	Resection	Fibroid tumor in transverse mesocolon	Recovery
Walters, W., and Priestley, J. T.	Surg. Clin. N. Amer., vol. 14, p. 643, June, 1934	Male, aged 34 yrs. Pain in lower abdomen for 8 yrs. Loss of appetite and weight. Relieved until 1932 when symptoms returned. Palpable tumor	Urachal carcinoma	Enucleation	Tumor in mesosigmoid	Recovery

Walters, W., and Priestley, J. T.	<i>Ibid.</i>	Male, 69 yrs. of age. Recurrent attacks of pain in the upper abdomen for 6 wks. Nausea and vomiting. Palpable tumor	Not stated	Inoperable. Biopsy	Huge lipoma in mesentery of jejunum	Not stated
Phillips, H. A.	Brit. Jour. Surg., vol. 21, p. 637, April, 1934	Female, aged 63 yrs. Swelling in abdomen for 4 yrs.	Not stated	Enucleation	Spindle cell tumor in gastrophatic ligament	Death 24 hrs. later
Phillips, H. A.	<i>Ibid.</i>	Female, aged 73 yrs. Swelling in right iliac fossa for 4 mos.	Not stated	Exploratory. Biopsy	Spindle cell tumor in great omentum	Died 8 weeks later
Kubo, M.	Mitt. a. d. med. Akad. zu Kioto, vol. 11, p. 302, 1934	Male, aged 39 yrs. Abdominal pain and tumor for 5 mos.	Not stated	Exploratory operation. Biopsy. Roentgen ray therapy	Osteosarcoma in the mesentery of the ileum	Died 55 days later
Finzi, O.	Boll. e mem. Soc. piemontese di chir., vol. 4, p. 1760, 1934	Female, aged 32 yrs. Slow growing tumor in right hypochondrium	Not stated	Resection of the terminal ileum, cecum, ascending colon and a part of the transverse colon	Fibroma of the mesocolon of the ascending colon	Recovery
van der Spek, J.	Nederl. tijdschr. v. geneesk., vol. 78, p. 5833, December 29, 1934	Male, 20 yrs. of age. Enlargement of the abdomen for 2 mos.	Abdominal tumor	Ileocecal resection	Fibromyoma in the mesentery of the terminal ileum	Died fourth post-operative day

been unaware. This was removed together with 36 inches of the small intestine. The histologic diagnosis was fibroma of the mesentery. At any time the "silent" variety may, as a result of some intra-abdominal accident, become active and the patient likewise be seized with an acute abdominal attack necessitating surgical intervention.

An early diagnosis of tumors of the mesentery is desirable. Bearing the condition in mind as a possibility is the first requisite in making a correct diagnosis. The early literature on the subject calls attention to the difficulty of correct preoperative diagnosis. Ransohoff and Friedlander⁸ state that the clinical diagnosis of mesenteric tumors is practically an impossibility. They further state that there are no pathognomonic signs or symptoms. Of the 86 cases reviewed and summarized in Table I, it is seen that the condition was correctly diagnosed 14 times before operation. It is not too much to suppose that the number of correct diagnosis would have been greater had the condition been considered and the examination directed with this thought in mind.

In several recorded cases of tumor of the mesentery the difficulties were so great and the appearances so puzzling that the operators did not recognize the true condition with the abdomen opened and the tumor before them. One merely closed the abdomen thinking the condition was malignant and inoperable; another failed to recognize the true nature of a huge lipoma of the mesentery and he likewise closed the abdomen. Both of these cases were later successfully operated upon elsewhere.

A "silent" but palpable abdominal tumor which may or may not be found in the region of the radix mesenterii, movable from side to side but not in an upward and downward direction, and that by roentgenologic examination can be shown to be extrinsic to the gastro-intestinal and the urinary tracts, should at least be suggestive of mesenteric pathology. In cases complicated with an intra-abdominal disaster the tumor may or may not be palpable and if there is a preëxisting history of a tumor with the above characteristics the true condition should likewise be thought of.

An added difficulty in diagnosis will arise in females where the possibilities of pelvic tumor must be considered. However, the nature of the majority of such growths can be determined by a careful pelvic examination. By placing the patient in a Trendelenburg position and thus utilizing the effect of gravity on structures outside of the pelvis, one will often be assisted in concluding whether or not the tumor originates in the pelvic structures. Reported cases of recent years indicate that correct preoperative diagnosis are being made more frequently.

The majority of solid tumors of the mesentery are benign and hence successful surgical removal will give a favorable prognosis. The degree of malignancy here is as a rule of a low grade. Metastases, with few exceptions, do not occur early. However, the cases should be watched for recurrences four, six, and ten years later. One of the cases reported by Rankin

and Major returned to the clinic six years after the primary operation with metastases in the liver.

Needless to say, the treatment of this condition is entirely surgical. Removal of the tumor with or without resection is the *sine qua non* to successful treatment, and this can be determined only at the time of the operation with the abdomen opened. If the tumor is so situated that it can be shelled out of the leaves of the mesentery without jeopardizing the blood supply to the adjacent bowel, resection of the intestine will then not be necessary. However, this may be a difficult matter to decide, and when in doubt it is safer to resect.

The question of resection of the bowel is not necessarily determined by the size of the tumor as evidenced by the case cited by Doran⁹ in which a fibroma weighing 30 lbs. was successfully enucleated without a resulting impairment of the blood supply to the intestine. The length of intestine removed has varied from a few inches to eight feet.¹⁰

The tumor may also be firmly attached to the surrounding structures by dense adhesions and hence the surgeon's judgment, dexterity and patience be taxed to the utmost. However, as Dr. W. D. Haggard has so fittingly stated, "The master craftsman in surgery, knowing the merits and prudence of each procedure, will unerringly select the correct method for the good of the patient."

SUMMARY

A case of fibrosarcoma of the mesentery is reported together with a review of the literature on the subject of solid tumors of the mesentery for the past 15 years. It is estimated that approximately 186 cases have been recorded up to the present time.

There is not always a unanimity of opinion among pathologists as regards the histopathologic diagnosis of solid tumors of the mesentery.

The cases present one of two groups of symptoms; one, the "silent" tumor with few if any symptoms, and two, those having vague abdominal symptoms of increasing importance up to the acute surgical abdomen produced by the mechanical effects of the tumor or rupture with hemorrhage and peritonitis.

As a rule, the malignancy of such tumors is of a low grade, but the cases should be observed for recurrence years later.

The diagnosis before operation is being made more frequently in recent years so that the correct preoperative diagnosis is no longer purely a matter of good fortune but of design.

The problem in treatment is to decide whether the tumor can be removed with or without resection of the involved segment of intestine.

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MECHANISM AND SIGNIFICANCE OF OBLITERATION OF THE LUMEN OF THE VERMIFORM APPENDIX*†

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A STUDY of the mechanism of obliteration of the vermiform appendix was undertaken in an effort to answer the following questions raised in reference to appendiceal obliteration:—Does obliteration of the appendix result from normal physiologic involution or is it caused by inflammation; or is it a combination of both of these processes? Just how does the appendix obliterate? Why is the appendix the only structure of the adult gastro-intestinal tract to undergo an obliteration of its lumen? Is the presence of lymphoid tissue in the submucosa of the appendix of significance? Why should the appendix possess comparatively more lymphoid tissue than found elsewhere in the intestinal canal? How should one regard the so called "reaction centers" in the appendiceal lymph follicles? Why should the appendiceal submucosa be the only portion of the intestine to contain large amounts of adipose tissue? What is the origin of this adipose tissue?

Can Masson's¹¹ contentions that neuromata formation plays an important rôle in obliteration be substantiated? Is he correct in his assumption that the sympathetic nervous plexuses play a major rôle in the formation of new connective tissue in obliterated appendices? Do Mallory's¹⁰ views on the importance of endothelium in the production of new connective tissue apply in the case of appendiceal obliteration? Are lymphocytes a factor in this obliterative process? How are we to evaluate Maximow's insistence of the polyblastic abilities of lymphocytes? Is there any relationship between obliteration and the so called "carcinoids" of the vermiform appendix? Finally, what should be the attitude of the surgeon when encountering an obliterated appendix during an abdominal exploration? What is the clinical significance of such an obliterated appendix vermiformis?

The source of the data upon which this study is presented was derived from 1,054 appendix specimens obtained from consecutive unselected post-mortems conducted in the Section on Pathologic Anatomy of the Mayo Clinic. This material was collected in a period of one and one-half years. Three hundred additional appendices were studied during a six months' period in the Section on Surgical Pathology at St. Mary's Hospital, Rochester, Minn. These two sources afforded a means of comparison between post-mortem and surgically removed appendices. It was noted that more surgically

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removed appendices were obliterated and showed more definite signs of inflammation than those removed during the performance of a routine post-mortem examination, in the same age groups. This is what one would naturally expect to find, since the surgical specimens had been removed because of either a history of or signs of appendicitis.

The following procedures were employed with the postmortem appendices:—Upon opening the abdominal cavity, the position and the relationship of the appendix to neighboring abdominal contents was carefully noted *in situ* before the abdominal contents were disturbed. Adhesions, "Jackson's veil" and "Lane's kink" were carefully studied and their incidence tabulated. Examples of the failure of the cecum to rotate or to descend into the right lower quadrant of the abdomen were carefully observed. The ceca were classified into one of the four types of Treves'¹⁶ classification. The appendix was then measured as to its length and average diameter. The specimen was then removed at the appendicocolic junction. Three routine transversely cut blocks of tissue were taken from each appendix. The levels for the three blocks were as follows: 1 cm. from the tip of the appendix, through the middle third of the specimen, and lastly through the proximal third, $\frac{1}{2}$ cm. from the appendicocolic junction. Two sections were cut from each of the three blocks of tissue, one being stained with hematoxylin and eosin and the other section with Van Gieson's connective tissue stain. The first stain depicted the finer cellular details, while the latter was of great value in studying the amount of connective tissue present and the relationship it bore to the process of obliteration. If interesting gross specimens were found showing important pathologic conditions, they were first photographed before microscopic study was undertaken. After the gross tissue blocks were cut for microscopic study, the remaining portions of the appendix were slit open with a pair of fine blunt-pointed scissors and the gross condition of the mucosa and lumen was noted. Abnormalities were searched for. In each instance a gross diagnosis was made as to whether or not any obliteration of the lumen was present and later compared with the microscopic findings. The diagnosis was correct in only 61 per cent of the gross estimations as to the presence or absence of lumen obliteration. The error occurred, in the great majority of instances, in failing to recognize the very early degrees of lumen obliteration. Careful records were kept of the gross and microscopic findings in each specimen together with a review of the history of the patient and the chief pathologic findings discovered at postmortem. If upon microscopic examination interesting findings were encountered, new sections were cut from the original tissue blocks and various other specific stains were employed to delineate more clearly the cellular details. The following special stains were used: Mallory's aniline-blue, Mallory's phospho-tungstic acid, Brown's modification of the Gram-tissue stain, specific stains for elastic and collagenous connective tissue, and various silver stains designed to bring out neurogenic details. The microscopic sections of the material studied totaled approximately 14,000.

Some of the findings derived from this study are as follows: approximately 61 per cent of this series of 1,054 specimens had patent lumina, while 39 per cent showed varying degrees of lumen obliteration; 61.4 per cent were males and 38.5 per cent were females; 58.6 per cent of the appendices were either anterior or hung free in the abdominal cavity while the remaining 41.4 per cent were bound down in a retrocecal position. In the specimens derived from those whose age was less than 50 years, more appendices were stenosed and still contained lymph follicles in varying degrees of preservation. This latter observation shows that the appendices were for the most part either just obliterating or had recently become stenosed. This fact argues that probably inflammation brought these changes about, because it is still rather early for physiologic involution of the lumen and appendix.

Seventy-five point eight per cent of this series contained specimens which measured between 5 and 9 cm. in length. In this study, the 648 male appendices averaged 7.4 cm. in length while the average length of the 406 female specimens was 6.7 cm. Thus, the male specimens averaged 0.7 cm. more in length. This peculiar fact had been previously noted by Berry^{2, 3} and by Fawcett and Blatchford⁵ in smaller series of cases. Seventy point four per cent of the series were derived from individuals between the ages of 30 and 70, the appendices being fairly equally divided among the four decade age groups.

The fact that more than 50 per cent of the specimens in each age group were not obliterated until the seventh decade was reached clearly shows that the theory of the involutionary origin of appendiceal lumen obliteration cannot entirely explain the mechanism of such a process. Even in the ninth decade of this series, 35.0 per cent were still patent in their entirety. Little actual lumen stenosis began before the age of 40 years. In the first four decades at least 71.1 per cent of each age group had completely patent lumina. It was not until the fifth decade was reached that total obliteration of the specimens actually appreciably began. Above the age of 50 years, obliteration is fairly equally divided between that involving the distal third, the distal two-thirds and that of the entire appendix.

The earliest obliteration of the distal third of a specimen in this series was found in an eight and one-half months old fetus. The latest obliteration confined to the tip alone was present in an appendix of an individual aged 84. The earliest total obliteration of a specimen occurred at the age of 12, while the oldest total lumen stenosis was discovered in a specimen obtained from a male whose age was 96. The ages in this series for the various types of obliteration are much greater than those reported by MacCarty and McGrath which they had derived from surgically removed specimens. This is what one would naturally expect to find when a comparison is attempted between these two different sources of anatomic material. This fact also suggests that obliteration of the appendiceal lumen must occur usually years earlier than when the postmortem specimen was obtained.

It is only above the age of 40 that total lumen obliteration is present to any appreciable degree in the specimens, varying from 10.4 per cent at the

age of 40 to 12.8 per cent at the age of 80. In the ninth decade this figure rose to 25.0 per cent, while in the tenth decade it was 100.0 per cent. However, in the ninth and tenth decade age groups there were only 21 specimens and consequently these percentages are of little significance. It was found that 39.08 per cent of the entire series had either partial or complete obliteration of the lumen. This is a considerably higher figure than those given in the literature. This wide discrepancy is probably explainable on the basis that in this series many early partially obliterated specimens were discovered only upon microscopic study. Grossly, there was failure to recognize 35.1 per cent of the appendices showing early lumen stenosis.

The percentage of all types of lumen occlusion in each age group rose steadily from 3.1 per cent in the first decade to 65.0 per cent in the ninth decade. However, between the third and ninth decades, the percentage for obliteration of the distal third of the lumen only varied between 20.8 and 22.0 per cent. This suggests that obliteration probably began early in adult life from inflammatory processes. Of the 412 examples of lumen stenosis obtained from this study, 22.74 per cent occurred before the age of 40, while 80.58 per cent were between the ages of 30 and 70. Only 7.92 per cent of these instances of obliteration were encountered under the age of 30, whereas merely 12.24 per cent occurred after the age of 70.

There were 254 appendices (24.2 per cent) less than 6 cm. in length. From the material of this study, the shorter specimens revealed higher percentages of obliteration than did those specimens whose length was greater than 6 cm. This percentage varied from 66.0 per cent for appendices 1 cm. long to 53.4 per cent for those 5 cm. in length. The average percentage of lumen occlusion for these short forms was 45.8 per cent; while the average for the remainder of the specimens 6 cm. or more in length, was 29.6 per cent.

Thirty-two point five two per cent of the anteriorly situated appendices were stenosed, while 48.39 per cent of the retrocecal specimens had a similar lumen atresia. Seventeen point one five per cent of the anterior cases and 18.34 per cent of retrocecal types possessed occlusion of the distal third of the lumen. Seven point nine two per cent of the anteriorly situated specimens and 14.67 per cent of the retrocecal forms had lumen obliteration of the distal two-thirds. Only 7.44 per cent of the anterior appendices were totally obliterated, whereas 15.36 per cent of the retrocecal cases presented a similar finding. These figures show that more retrocecal specimens were obliterated than were the free anterior forms. Since obliteration of the vermiform appendix is usually caused by a previous inflammation, therefore probably more retrocecal specimens were originally subjected to inflammation than were the free anterior cases. Undoubtedly many retrocecal appendices derived their location from a previous inflammatory process.

Thirty-two appendices (3.08 per cent) of the 1,054 specimens of this study demonstrated abnormal types of lumen stenosis, in that the occlusion was not progressing continuously, as it ordinarily does, from the tip towards the base. Eighteen specimens (56.8 per cent) of this group revealed the most marked obliteration of the lumen to occur in the middle third of the appendix.

Four instances (12.5 per cent) were encountered in which the tip and base were obliterated, but the middle third of lumen of the specimen was patent. Five examples (15.6 per cent) of occlusion were found where the process was most advanced in the proximal third. In two appendices (6.25 per cent) the proximal third of the lumen was the only portion to be obliterated. Three instances (9.37 per cent) were obtained in which the middle third only of the lumen revealed lumen atresia.

Five "carcinoid tumors" (0.47 per cent) were found in the 1,054 specimens. All were situated in obliterated portions of the former appendiceal lumen. In four instances the tumor occurred near the tip of the appendix, while the remaining case was situated near the appendiceocecal junction. Thus, one "carcinoid" occurred to every 82 plus obliterated specimens. MacCarty and McGrath⁹ found the incidence to be one "carcinoid" to 53 partially or totally obliterated appendices.

There are apparently two chief processes by which the inflammatory type of obliteration of the appendiceal lumen may develop. The first is the more common. Following an attack of acute or subacute appendicitis which subsides by resolution, the mucosa is either partially or totally destroyed and the inflamed portions of the lumen, now unprotected by a lining of mucosa, adhere together and later become solidly fused. The crypts of Lieberkühn, which are the source of new mucosal regeneration, cease to function in this capacity and are destroyed. They then undergo atrophy and rapidly disappear. It is believed that the extensive loss of the mucosa is responsible for the rapid destruction of the crypts. In the newly obliterated appendiceal lumen, a large number of lymphoid follicles and considerable collections of small lymphocytes alone are remainders of the necrotic mucosa and portions of the submucosa. Under the stimulus of repair following inflammation, the polyblastic tendencies of the reticular endothelium and lymphoid tissue quickly become manifest. The "reaction-centers" of the lymph follicles rapidly disappear. The follicles themselves persist for considerable periods of time after the obliteration of the appendiceal lumen has occurred.

A typical inflammatory type of coarse reticular connective tissue is derived from the large amount of submucosal reticulum remaining as well as from endothelium and fibroblasts present in the interfollicular layer of the submucosa. A further important source of this new tissue originates from the vascular and lymphoid sinusoidal endothelium as well as from lymphocytic tissue. This newly formed coarse reticular connective tissue, as it grows older, changes into hyaline-collagenous connective tissue. Usually large portions of the submucosa are destroyed by the primary acute or subacute inflammation responsible for the lumen obliteration. This leaves in its wake a skeletal framework of supporting hyaline connective and reticular endothelial tissues which were originally present in the submucosa. Soon the intervening spaces in this scaffolding are filled by adipose tissue, derived mostly from normal fatty tissue of the meso-appendix. This new adipose tissue probably enters the area of the submucosa by migration in along the perforating blood

vessels. Some of this new tissue may originate from the submucosal lymphoid-endothelial-reticular structures.

The formation of reticular connective tissue increases as lymphocytic tissues present in the obliterated lumen region disappear. This newly formed connective tissue spreads in a stellate manner through the submucosa from the former site of the lumen peripherally towards the juncture with the circular muscularis. This juncture between the submucosa and the muscularis is the last portion of the submucosa to be replaced by recently formed hyaline connective tissue. The farther away the connective tissue is from the former site of the appendiceal lumen, the older it is and the greater is the likelihood that it will be of a hyaline-collagenous type. Elastic connective tissue is usually not encountered in appreciable amounts in obliterated appendices.

The newly formed inflammatory type of reticular and collagenous connective tissues can be readily distinguished from the normally present older reticulum and hyaline collagen. In the newer tissues, the following histologic details may be readily recognized: the fibrils and fibers are coarser, the nuclei are larger and present immature histologic characteristics; the cytoplasm is more granular and contains large numbers of fine fibrils in its composition; and finally, these tissues characteristically stain a lighter color with specific connective tissue stains than do normally present hyaline connective tissue elements. The type of reticulum and collagen encountered in an obliterated appendiceal lumen is quite comparable to that observed in granulation tissue and in scars that heal by secondary intention elsewhere in the human body. This is a further argument in favor of its inflammatory origin.

The second process of appendiceal obliteration is less commonly seen. It is in reality only a modification of the first type and the basic principles responsible for the ultimate obliteration of the lumen are the same. In this group the mucosa has been subjected to numerous mild subacute inflammations which were insufficient to totally destroy it, however, enough areas of the mucosa and submucosa are injured from time to time to initiate the endothelial, lymphoblastic and fibroblastic formation of new reticular tissue, in either large or small amounts, depending upon the degree of stimulus derived from the inflammation. Often the inflammatory process may cause a thrombosis of the submucosal blood vessels with a resultant localized infarction of areas of the submucosa and mucosa. After several such incidents, the lymphoid tissue bordering the limits of the lumen is markedly reduced. The submucosa is replaced with considerable collections of hyaline collagenous connective tissue and with a minimum of reticular tissue. The lumen is markedly narrowed by this hyaline connective tissue proliferation. Finally, the lumen is obliterated in one of the following two ways: (1), by the pressure atrophy of the mucosa resulting from encroachment of the increasing hyaline connective tissue originating from inflammatory stimulated submucosal tissues and from preexisting hyaline connective or endothelial tissue elements; (2), by an additional acute inflammation which finally destroys so much of the mucosa that it cannot be regenerated by the decreased number

of functioning crypts of Lieberkühn, before adhesion to the opposite wall occurs.

Various modifications of these two processes may be encountered in a large group of specimens. However, the mechanism of the formation of the lumen occlusion is fundamentally the same. Localized acute inflammations of the lumen may totally destroy narrow areas of the mucosa and cause the formation of the so called "diaphragmatic" or "thick" occlusions of Maale.⁷ If such a process occurs near the appendiceal base and if the portion distal to the resultant limited obliteration has an intact mucosa and can overcome the residual inflammation present in the now sealed off cavity, a mucocele of varying size may result. If the resulting cavity is unable to cope with the inflammation remaining in the lumen, an acute fulminating gangrenous appendicitis with probable perforation may result.

In this study it soon became apparent that the only specimens in which to intensively study the histologic changes occurring in obliteration were those either just undergoing obliteration or the junction line of those in which obliteration was slowly extending from the tip towards the base. Both types of material were studied, using many varieties of histologic stains to bring out selectively all of the component tissues. It was soon noted that the neurogenic tissues in the specimens were not responsible for the lumen atresia. Many types of nerve tissue stains were used before reaching this conclusion. In no specimen could Masson's contentions be substantiated. Therefore, attention was focused upon the histologic appearance of early beginning obliteration and upon the junction zone between the obliterated and patent portions of the lumen, in an effort to learn how obliteration originated.

In specimens showing early beginning obliteration of the entire lumen, the following histologic details are commonly seen: there are large collections of small lymphocytes, plasma cells, mast cells, polymorphonuclear eosinophils, monocytes, fibrocytes, endothelial cells and histocytes found largely in the submucosa, obscuring the normal histologic details of the appendiceal wall. The greatest aggregations are found in the interfollicular layer of the submucosa. Isolated groups of small lymphocytes are found often about the lymphatic vessels and the veins or arteries of the muscularis. The mucosa may become entirely destroyed, or, on the other hand, only localized areas undergo necrosis. The lumen becomes filled with mucosal cellular debris and by cellular elements from the submucosa. Usually few polymorphonuclear neutrophils are seen in such an histologic picture after the initial inflammatory process has occurred. The crypts of Lieberkühn undergo varying degrees of destruction and are thus unable to regenerate the mucosa needed to keep the lumen patent. The crypts that escaped injury are insufficient to perform this task and soon disappear. The lymph follicles reveal varying amounts of disintegration. Their "reaction-centers" promptly disappear. The architecture of the follicles is often markedly distorted by efforts towards restoration of function. Marked endothelial hyperplasia of the lymphatic sinusoids is commonly observed. Lymphocytes are mobilized *in situ* in the appendiceal

submucosa. Marked phagocytosis may be seen in the submucosa and particularly in the interfollicular portion.

The small lymphocytes, histocytes and monocytes are the chief actors in the process of phagocytosis. Often endothelial proliferation of the submucosal capillary network may be seen, giving rise to many free endothelial cells. Often considerable numbers of adult erythrocytes are observed in the midst of this process. Occasionally small embolic abscesses and thrombosed blood vessels are found in the submucosa. Frequently, a large fecolith fills and dilates the lumen causing erosions and irreparable damage to the mucosa. These breaks in the protective lining of the mucosa allow the entrance of bacteria into the submucosa, thus initiating inflammation there. Probably the fibrosing action of *Escherichia coli* and of *Streptococcus fecalis*, as pointed out by Adami, may be important factors in the production of new connective tissue in the submucosa. Some of my findings agree with those of Steinberg described by the term of "degenerative appendicosis." During this stage in obliteration the mucosa and portions of the submucosa demonstrate their necrosis by failing to stain or to reveal cellular details when tissue stains are employed. Following phagocytosis, a lacework of reticular connective tissue alone remains of those portions of the mucosa and submucosa which were destroyed. The areas between the fibrils of this mesh sooner or later become filled with adipose tissue. The adipose tissue is observed to make its first appearance in the immediate perivascular areas of the remaining patent arteries in the submucosa. This tissue then spreads to other portions of the submucosa. Some evidence also points to the partial origin of adipose tissue from interfollicular endothelium and lymphoid structures.

Careful studies show that the new reticulum formation originates in the interfollicular area of the submucosa from vascular and lymphoid sinusoidal endothelium as well as from remaining lymphocytes and fibrocytes. Maximow,¹³ Bloom,⁴ and Palmer and Higgins¹⁴ all agree that fibroblasts may arise from lymphocytes. Mallory¹⁰ has clearly shown that endothelium also serves as a source for the production of reticulum. If any lymphoid structures remain in the obliterated portion after resolution of the inflammation, the subsequent formation of new hyaline collagenous connective tissue is correspondingly increased. Van Gieson stains clearly show that the newest connective tissue originates in the area comparable to the site of the former interfollicular layer of the submucosa. The oldest hyaline connective collagenous tissue is found adjacent to the junction line with the muscularis. Here, however, the amount of hyaline collagenous connective tissue is markedly less than that found occupying the central area of the site of the former lumen. This new tissue extends in a stellate manner peripherally. No evidence was obtained from this study that will substantiate the assertion that this newly formed reticular connective tissue was derived from adult endothelium of blood vessels or from older adult hyaline collagenous connective tissue situated in the peripheral portions of the submucosa.

As time goes on, the central area of the oblitative phenomena becomes

more and more replaced by collagenous hyaline connective tissue. Staining reactions clearly continue to demonstrate that the source of this new tissue proliferation is in the central portion of the former submucosa. The amount of adipose tissue progressively diminishes, until only small localized collections may be observed about the remaining patent arteries in the peripheral portions of the former submucosa. Sometimes the entire area of the former submucosa becomes completely replaced by hyaline collagenous connective tissue. There is a progressive arteriosclerosis and endarteritis of the blood vessels. As a consequence of this condition and due to atrophy from disuse, the muscularis undergoes considerable atrophy. Usually Meissner's plexuses are completely destroyed during the process of repair following inflammation or during obliteration. The plexuses of Auerbach often are seen to undergo slight but definite degrees of hyperplasia in obliterated specimens. However, I believe that "carcinoid tumors" of the appendix are probably usually derived from submucosal epithelioneurogenic elements.

The histologic picture sketched above may vary in marked degree from large cellular collections, extensive mucosal destruction, and complete replacement of the former submucosa with new hyaline collagenous connective tissue, to an histologic picture in which one or all of these cellular changes may be present to only a slight degree.

In specimens showing a definite junction line between the obliterated and patent portions of the lumen, similar cellular changes of much less extent and severity are usually to be seen. It is only in the limited area of the juncture that any evidence of the presence of inflammatory processes may be detected. In as much as the same cellular processes are responsible for this type of progressive obliteration of the lumen as were just described above, I shall not repeat them. A progressive diminishment in the blood supply to the distal portion of the appendix may be an important factor in its causation, aided by a low grade inflammation.

From the foregoing descriptions, it is apparent that inflammation is largely responsible for such an histologic picture, but it must be remembered that involution also plays a contributing rôle.

Many factors play important rôles in the production of obliteration of the appendiceal lumen: the *first factor* is that the vermiform appendix in man represents a vestigial structure whose functions in human physiology are little known and are apparently of slight consequence. As various stages in mammalian development are ascended, the appendix becomes more and more a vestigial structure with a progressively diminished lumen which has an increasing tendency towards stenosis.

The *second factor* is that the blood supply to the appendix is of the terminal type, meaning that the distal two-thirds is solely supplied by non-anastomosing end-branches of the appendiceal artery. The appendix has no other appreciable source of vascular supply aside from the appendicular artery. It is obvious from such a vascular arrangement that the tip of the appendix may receive a much lessened blood supply than other portions

nearer to the cecum. Furthermore, any process which causes a narrowing and diminishment in the lumen of the appendiceal artery necessitates that the tip of the appendix must obviously be the first portion which may be deprived of adequate nourishment. It is thus apparent why the tip of the appendix is the most common situation where lumen obliteration has its inception and why this stenosing process later extends progressively proximally towards the base of the appendix. In this study several specimens were obtained from individuals who died before the age of 25 from so called "malignant hypertension." All of these appendices showed rather advanced complete lumen obliteration.

The *third factor* of this discussion is that all humans after having reached maturity, at about the age of 25, begin a steady but slow retrogressive involution of all body tissues. This process occurs faster in those tissues, such as the appendix, which have no appreciable physiologic function. In individuals over the age of 25 we are in the presence of tissues already slowly becoming senescent.

The *fourth factor* is that capillary beds of all parenchymatous organs, as the brain, kidneys, spleen, *etc.*, undergo a progressive and definite obliteration after physical maturity is reached during the third decade. There can be little doubt that this process occurs to a considerable degree in the appendix.

The *fifth factor*, having a bearing upon this problem, is the recognized observation that the human appendix is notoriously unable to cope with even a mild infection, which occurring elsewhere in the body would be of little consequence. However, in the appendix, gangrene and perforation frequently result. This serves as additional evidence of the inadequacy of the terminal type of its vascular supply. The actual volume of blood reaching the appendix tip must be considerably less than that supplying the base, and that is probably why gangrene and perforation usually occur at the tip in acute appendicitis.

The *sixth factor* in this consideration is the peculiar tendency of adipose tissue to collect in the appendiceal submucosa. The adult appendix is a vestigial structure, possessing poor peristalsis, having a poor inadequate blood supply and a natural tendency towards involution. The fat of the meso-appendix apparently migrates in along the course of the perforating blood vessels as they ramify from the meso-appendix to the submucosa. This occurs in the appendix normally to the exclusion of other portions of the gastro-intestinal tract due to the factors mentioned above. Adipose tissue is probably a visible expression of the static regressive condition of the vermiform appendix.

The *seventh factor*, that obliteration of the appendix is found more frequently in older individuals, is more apparent than real. Probably a large number of these specimens were obliterated by an inflammatory process early in life. Obliteration apparently occurs predominantly in "civilized" races. Surgically removed specimens reveal a greater percentage of lumen obliteration than do those obtained at postmortem, both groups being derived from

individuals varying in age from 11 to 29. This fact substantiates the contention that inflammation plays an important rôle in the production of lumen atresia. The facts that many individuals more than 60 years old of age still possess patent appendices, and also that the percentage of lumen obliteration between the fourth and eighth decades of life show little progressive increase with age, strongly argues against the contention that obliteration is mainly dependent upon senescent involutionary factors alone, or chiefly, for its causation. The finding of specimens of obliteration which begin in portions of the lumen distant from the tip and often in several widely separated locations at once, support the inflammatory origin of such changes in the lumen. The presence of "carcinoid tumors" in obliterated portions of the lumen may argue that such tumors had their origin from inflammatory stimulated epithelial or argentaffine cells in or near the crypts of Lieberkühn or from portions of Meissner's plexuses which had remained behind as isolated nests of cells in the inflammatory produced lumen obliteration.

The *eighth factor* is that the histologic appearance of the obliterated appendiceal lumen at the time of the occlusion strongly argues its inflammatory origin.

The *ninth factor* is that all structures containing an excess of lymphoid tissue normally have a tendency to undergo involution after maturity has been reached. The appendix certainly has an apparent excess of lymphoid tissue.

These nine factors are the chief contributing agents to this complicated consideration of the production of obliteration of the appendiceal lumen. The data from this study present evidence that involution is usually either a predisposing or a terminal process in appendiceal obliteration; but that inflammation is the main causative factor which actually and initially institutes the lumen stenosis.

CONCLUSIONS

Obliteration of the appendiceal lumen occurs largely as the result of a previous inflammation which destroys the mucosa and portions of the submucosa. Physiologic involution is a contributing factor in appendiceal lumen stenosis. Data on these two facts have been presented. Many appendices remain entirely patent during the life of the individual even though he live until the ninth decade. The source of the new hyaline connective tissue which obliterates the former lumen is partially derived from the lymphoid-endothelial tissues present in the interfollicular layer of the submucosa. This fact has not been sufficiently stressed in the past.

Normal and abnormal collections of submucosal adipose tissue are in part derived from lymphoid-endothelial elements. However, most of this adipose tissue probably reaches the submucosa by a simple process of migration in from the meso-appendix along the course of the perforating blood vessels. The amount of fat in the submucosa of the appendix bears slight relationship to the state of nourishment of the individual.

"Reaction centers" in lymph follicles remain in patent functioning ap-

pendices during the life of the individual, even though he live far beyond his expected span of "three score years and ten." These "centers" represent visible expressions of the active physiologic activities on the part of the lymph follicle towards inflammation.

Obliteration may begin in any portion of the appendiceal lumen and extend either towards the tip or towards the base. Blind cavities may be left by this process which may become mucoceles, cysts, or empyemas depending upon the circumstances in each case. Usually obliteration begins at the tip and extends proximally towards the base. The mechanism of the two chief methods by which the appendiceal lumen is obliterated has been carefully described. The histologic picture of beginning obliteration was delineated in detail.

"Carcinoid tumors" of the appendix usually occur in obliterated portions of the lumen.

Most appendices are anterior in position. More retrocecal specimens are obliterated and hence in the past they were probably originally subjected to more frequent inflammation than the present free anterior appendices. The male appendices averaged 0.68 cm. more in length than did the female specimens. Apparently, shorter appendices become more easily inflamed and consequently obliterate more frequently than do specimens averaging more than 6 cm. in length.

Inflammation is the chief initiating agent of appendiceal obliteration. This is especially true in specimens derived from individuals under the age of 35. Above this age involution may partially initiate or complete the final stages of the obliterative process. The reason why the appendix is the only portion of the adult gastro-intestinal tract to undergo obliteration may be explained upon the basis of inflammation, senescent involutionary tissues, inadequate terminal blood supply, poor peristalsis and inability to overcome infections that elsewhere in the intestine are of trivial consequence.

The appendix possesses an apparent increase of lymphoid tissue over that of the rest of the gastro-intestinal tract, which is explainable by the embryologic fact that the appendix represents a considerable portion of the adult cecum which failed to assume its normal dilated state. The lymphoid tissue in the appendix is merely a condensation of what was originally intended to serve a much greater surface area.

I have been unable to find proof from this study that the sympathetic nervous plexuses of the appendiceal wall or neuromata formation from argentaffine cells play any appreciable rôle in the formation of new connective tissue present in obliterating appendices. Mallory's views that endothelium and Maximow's contentions that lymphocytes possess polyblastic abilities to produce new reticular connective tissue under the stimulus of inflammation can be fully substantiated in the case of obliteration of the appendiceal lumen. These two cellular elements are important factors in the production of obliteration.

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POSTANGINAL SEPSIS

CAUSED BY A NEWLY DESCRIBED HEMOPHYLIC ANAEROBIC BACILLUS

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MANY cases of postanginal jugular thrombophlebitis with sepsis have been reported during the past decade, principally by German authors. The historic review of this condition has been repeatedly given in previous communications of various authors. This paper is presented to describe a carefully studied case of postanginal sepsis caused by a previously undescribed etiologic agent.

CASE REPORT

Case 11338.—T. McC., a colored widow, aged 24, was admitted September 8, 1933, to the Otolaryngologic Service of Dr. Samuel Iglauer at the Cincinnati General Hospital. The patient complained of unilateral (right) sore throat of five days' duration associated with dysphagia, inability to open the mouth, generalized aching of the muscles, headaches and an indefinite history of nightly chills since the onset of the sore throat.

Physical examination revealed a well developed, well nourished adult colored female, who appeared moderately ill, uncomfortable, and unable to open her mouth widely. Examination was essentially negative except for the local findings. The heart and lungs were not remarkable with the exception of the rapid pulse and respiratory rate.

Temperature, 104° F.; pulse, 112; respirations, 28. Blood pressure, 130/90. A large peritonsillar abscess was found on the right side. This was incised and a large amount of thick grayish-yellow pus with a foul odor was evacuated. Culture was negative. White blood cells, 18,000. The abscess was reopened on the following day.

The course of the illness was progressively downhill, the temperature remaining high and the patient becoming very toxic. On September 16, a swelling beneath angle of right mandible, suspected of being a parapharyngeal abscess, was operated upon by Dr. Samuel Iglauer. The internal jugular vein was filled with thick, creamy, putrid pus above a large thrombus at the level of the omohyoid muscle. The internal jugular vein was ligated below the thrombus, incised longitudinally, and drained with iodoform gauze. Culture was negative. However, on smearing and staining some of this pus, many intracellular gram-negative bacilli were observed. No coccus forms were seen. Culture under special conditions yielded an anaerobic, hemophilic, hemolytic, gram-negative bacillus in pure culture.

On the night of operation the patient experienced her first chill since her admission; it was severe and lasted 25 minutes. The temperature rose to 106.2° F.; pulse, 140; respirations, 30. She coughed frequently and complained of pain in the upper left abdominal quadrant.

Postoperatively the patient had many severe chills occurring irregularly from twice daily to once every other day. A soft systolic mitral murmur, which, in one week's

* The greater part of this work was carried on in the Department of Bacteriology of the University of Cincinnati and Cincinnati General Hospital, and completed at the Henry Ford Hospital, Detroit, Mich.

time, became loud, harsh and transmitted to the left axilla, was heard for the first time. Anaerobic blood cultures taken just after the onset of three of the chills yielded upon six days' incubation, the hemophilic anaerobe in pure culture. A blood culture taken with reference to a chill was negative.

The patient also developed abscesses of the left and right shoulder joints and left and right hip joints in the five-week period after operation. Upon incision of each of these, the pus yielded on cultivation the same anaerobe. Smears of the pus showed the organism as an intracellular bacillus. Terminally, just before death, blood cultures showed the anaerobic bacillus and a hemolytic streptococcus.

In spite of repeated blood transfusions, the patient's red blood cells and hemoglobin rapidly fell to 1,500,000 and 28 per cent, respectively. She expired October 24.

The autopsy was performed in the Pathologic Department of the Cincinnati General Hospital by Dr. Ralph Fuller.

Anatomic Diagnosis: "Visceral evidence of septicemia; cerebral venous septic thrombosis; cerebral congestion; possible early meningitis; multiple lung abscesses; perisplenic abscess; multiple pyarthrosis with surgical drainage; vegetative mitral endocarditis, possibly rheumatic; toxic myocardosis, nephrosis, and hepatosis; fatty infiltration of the liver, active vaginitis, endocervicitis, endometritis; chronic salpingitis; focal pleural fibrosis and slight aortic arteriosclerosis."

Microscopic Diagnosis: "Organizing cerebral venous sinus thrombosis and multiple pulmonary abscesses (active, atypical, pleomorphic, granulomatous reaction with numerous phagocytic macrophages and plasma cells); reticulo-endothelial hyperplasia in the spleen and lymph nodes; hemosiderosis and focal necrosis in the spleen; small verrucous scar on the mitral valve; myocardosis, edema and focal fibrosis in the myocardium; hepatosis, slight chronic pericholangitis; chronic passive congestion with central atrophy and fatty infiltration of the liver; low grade chronic salpingitis and vaginitis, active chronic cystitis; slight aortic arteriosclerosis."

Pyarthrosis was present in both shoulder and both hip joints, and large abscesses had extended into the soft tissues immediately adjacent to these joints. The anterior cusp of the mitral valve presented a small focal area of scar-like thickening in its mid-portion near the line of closure. Firmly adherent to the atrial endothelial surface of this focal valvular thickening was a small cluster of minute, dense, pale, verrucous vegetations. These little polyp-like projections were so firmly adherent to the endothelium that they could not be torn away with forceps. It is interesting to note that clinical evidence of organic, mitral insufficiency developed during the course of the patient's illness and increased rapidly.

In the lungs numerous, scattered, subpleural, small abscesses were found in the interlobar spaces between the right middle and lower lobes.

Multiple fibrous adhesions bound the spleen to the surface of the diaphragm and enclosed a small abscess cavity between the spleen and diaphragm.

The right lateral, sigmoid, and petrosal sinuses were found dilated and occluded by friable, pale-yellow thrombus.

The organism obtained from this case was a pleomorphic, gram-negative, hemophilic, hemolytic, obligate anaerobe. It was cultured with considerable difficulty, growth appearing in five to seven days only on media containing blood and only under strict anaerobic conditions. Best growth was obtained on fresh blood agar slants containing 0.2-3 per cent dextrose and 1.0 per cent agar. The growth is heaviest in the water of syneresis. Growth will occur on chocolate agar slant to a lesser degree; none was obtained on gelatin, soft egg, brain broth, Loeffler's or dextrose-ascites-agar unless a few cubic centimeters of sterile fresh blood were added. The strict hemophilic requirement has remained unchanged throughout one and one-half years' artificial cultivation.

DESCRIPTION AND PROPERTIES OF THE ORGANISM RECOVERED

Morphology: When first isolated the organisms showed a tendency toward thread formation. On further cultivation they lost this tendency and appeared as very pleomorphic, minute bacilli with rounded ends. No spore formation was observed.

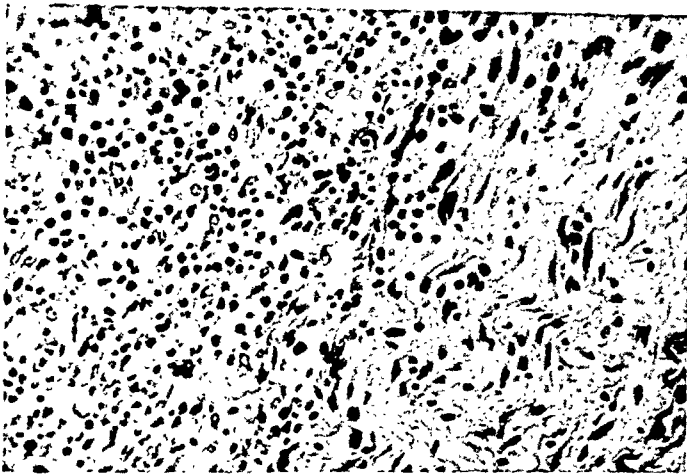


FIG. 1.—Section of wall of abscess in pectoral muscle showing atypical pleomorphic granulomatous cellular reaction with numerous phagocytic macrophages and plasma cells.

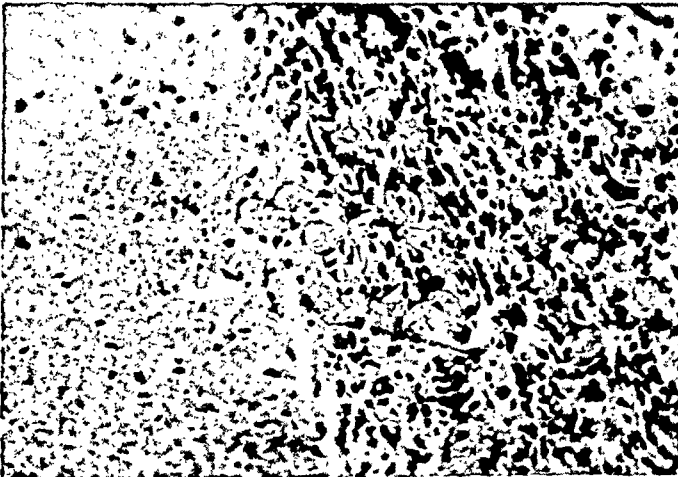


FIG. 2.—Section of lung abscess showing necrosis and abscess wall with granulomatous pleomorphic cellular reaction. Note the great number of phagocytic macrophages and plasma cells.

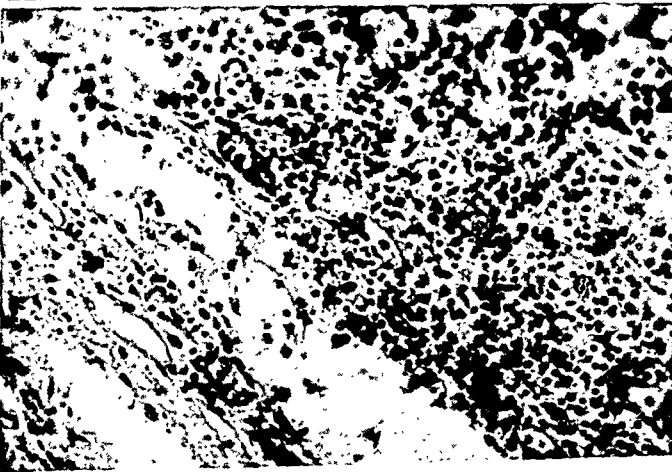


FIG. 3.—Section of cerebral venous thrombosis showing the same type of pleomorphic granulomatous cellular reaction.

Staining: The bacillus is stained with great difficulty by the usual anilin dyes. When stained by Gram's method, it appears as a faintly staining, small, gram-negative rod. Best results were obtained by five minute staining with steaming dilute (1:20) carbol fuchsin. When stained with Giemsa's stain or dilute carbol-fuchsin, the bacillus shows bipolar staining, especially after recent passage through a susceptible animal.

Motility: Nonmotile.

Growth: Strictly anaerobic. No growth obtained aerobically or under partial tension even after one and one-half years of artificial subcultivation. Good growth obtained with pyrogallic acid and Rockwell's solution. After inoculation of blood agar slants, no growth was visible with the naked eye until the fourth or fifth day when numerous, flat, minute, discrete, translucent colonies are first visible on the surface of the slant. Growth of the organism in the water of syneresis is manifested by a fine, flaky suspension. A very fetid odor was produced when this bacillus was cultured artificially, similar to that found in the fetid abscesses in the case presented.

Glucose, maltose, saccharose, lactose, mannite, xylose and levulose are fermented by the organism, with production of acid but no gas. Dulcitate, erythrite, inulin and galactose are fermented with the formation of acid and gas.

Proteolysis: No liquefaction of gelatin. No proteolysis of coagulated serum.

Milk: No growth in absence of fresh blood.

Nitrate Reduction: Nitrates are reduced to nitrites.

Indole Formation: No indole formed on tryptophan broth.

Animal Pathogenicity: Pathogenic for rabbits but nonpathogenic for guinea-pigs and mice. Eight guinea-pigs were injected subcutaneously or intra-abdominally with 2 to 4 minims of a saline suspension of seven to ten day old culture. These animals were all living and apparently well six weeks later. They were then autopsied. No pathologic findings were noted and the organism was not recovered from the heart blood in any case. Also, ten young mature mice were injected subcutaneously or intra-abdominally with 1 to 4 minims of a saline suspension of the organism. These animals were living and well six weeks later. Autopsy revealed no significant pathology. The organisms were not recovered in any case. Seven rabbits were injected intravenously with 2 to 5 minims of a saline suspension of the organism. All these animals died within 10 to 17 days. In the autopsied animals multiple abscesses of the lung, liver, and spleen were found in six instances, peritonitis centering about the liver in three instances, empyema and polyarthrosis each in two instances.

It is interesting to note that this organism apparently has a specificity for endothelial tissue as manifest by nature and location of the lesions produced both in the patient and the rabbit.

To prove that this bacillus was the etiologic agent in this case, the following facts are advanced:

(1) The organism was obtained in pure culture from the thrombophlebitis of the internal jugular vein and from each metastatic abscess at the time of their initial incision.

(2) The organism was seen in smears prepared from pus of each metastatic abscess as a very small, gram-negative rod.

(3) The bacillus was grown in pure culture from the blood stream on three occasions during the progress of the disease. Terminally, four days before death and at autopsy, a hemolytic *Streptococcus* was also found, but not before.

(4) None of the smears examined from abscesses showed *Streptococci* at the time of their initial incision.

(5) The patient gave repeatedly positive intradermal skin reactions to this bacillus.

(6) In the second month of her illness, the patient's serum agglutinated suspensions of this organism in dilutions up to 1,800.

(7) Artificial cultivation of this anaerobe produces the same fetid odor noted in the various metastatic lesions.

(8) The unusual microscopic picture of atypical, pleomorphic, granulomatous tissue reaction with numerous phagocytic macrophages and plasma cells is in favor of an unusual infecting organism rather than a *Streptococcus*.

During the past 18 months the literature has been reviewed in an effort to find a description of this bacillus. No mention of an anaerobic, hemophilic, hemolytic, gram-negative bacillus was found. Many anaerobes have been described chiefly by German writers as etiologic agents in cases of postanginal sepsis and other thrombophlebitic processes, and when present give a definitely poorer prognosis. This has been shown especially by Eugene Frankel⁷ and Kissling.^{15, 16, 17} Detailed studies of morphology, cultural characteristics, and pathogenicity are available for few of these organisms. In most instances it is simply stated a gram-negative bacillus was found either in pure culture or in association with a *Streptococcus*. Anaerobic *Streptococci* have been frequently found in the blood streams of such cases. Schottmuller^{4, 5} has described a gram-negative anaerobic bacillus found in association with the *Streptococcus putrificus* in cases of puerperal sepsis and in embolic putrid lung abscesses. He has named this bacillus, therefore, the *Bacillus symbiophiles*. Kissling has described 14 causes of postanginal sepsis in which he has obtained a gram-negative bacillus from the blood stream in pure culture. This organism he believes is identical with Schottmuller's *Bacillus symbiophiles*.

The bacillus obtained from the case here presented is strictly hemophilic, definitely hemolytic, and pathogenic for rabbits, while Schottmuller's *Bacillus symbiophiles* is not hemophilic, is not hemolytic, and is nonpathogenic for rabbits, guinea-pigs, or mice (Nedelmann²⁰). Complete bacteriologic studies of *Bacillus symbiophiles* have been hindered by the great difficulty of separating it from the *Streptococcus putrificus*.

Eugene Frankel (1925) presented ten cases of postanginal sepsis, first pointing out the importance of anaerobic bacteria in the etiology of thrombophlebitis. He also stated that the putrid character of the metastatic abscesses bespeaks the anaerobic nature of the etiologic agent. He reported a gram-negative, anaerobic bacillus found in pure culture in one case and in association with various anaerobic *Streptococci* in others. No detailed bacteriologic studies of these bacilli were presented.

H. Lenhartz reported five cases of postanginal sepsis in which he found gram-negative anaerobic bacilli in the blood stream in three of the cases, in pure culture in one instance, and in association with anaerobic *Streptococci* in two cases. Bacteriologic studies were not given.

Wirth has described a gram-negative anaerobic bacillus as an unusually virulent cause of acute middle ear disease. This is probably identical with that described by Schottmuller and Kissling.

E. Nedelmann, in 1928, reported a case of pyelophlebitis and sepsis complicating appendicitis, in which he demonstrated an anaerobic, gram-negative bacillus in the blood stream in pure culture. After studying this organism he concluded it was identical with the *Bacillus symbiophiles* of Schottmuller.

In 1931, H. E. Mansell²³ described a case of suppurative arthritis caused by a hemophilic bacillus in a nine months old infant. This organism was found to be gram-negative, very difficult to grow, and nonpathogenic for guinea-pigs. No further bacteriologic findings were given; no statement was made as to the oxygen requirements of this bacillus.

Victor K. Russ described a slowly growing, anaerobic, small, easily stained, gram-negative bacillus which he obtained from a peri-anal abscess in association with a short-chain *Streptococcus*. He was impressed with the similarity of this organism and the influenza bacillus both morphologically and culturally. However, the bacillus was not strictly anaerobic, and could be cultured on dextrose nutrient agar in the absence of blood. No mention was made of any hemolytic properties. Unfortunately, he was unable to culture the *Streptococcus* artificially which he had observed in the stained smears. Doctor Russ injected only mice with saline suspensions of this organism and was unable to demonstrate any pathogenicity. He concluded the bacillus was a saprophyte in an abscess caused by the short-chain *Streptococcus*.

F. W. Hartman and E. Jackson,²¹ in 1930, reported a gram-negative, essentially hemophilic bacillus from a case of fatal meningitis. This organism grew aerobically, however, and on dextrose ascitic agar in the absence of blood. It was not hemolytic, and it was pathogenic for guinea-pigs, rabbits, monkeys and dogs.

Numerous typical cases of thrombophlebitis with sepsis and metastatic abscesses have been described in which all attempts to obtain positive cultures from the blood or pus were either entirely unsuccessful, or yielded terminally just before death a *Streptococcus* or *Staphylococcus*. Kissling reports four such cases in which anaerobic bacteria were suspected but never demonstrated. It is suggested that those cases may be caused by an anaerobe similar to the one here described which is relatively difficult to culture, and that many of these cases would yield positive cultures with better methods of culture. It is interesting to note here the explanation given by Libman and Celler²² for the negative blood cultures they obtained in cases of sinus thrombosis of infectious origin:

"We are inclined to believe that early there may be no bacteremia, that the bacteria may then be found perhaps in increasing numbers, and that it is possible for the bacteria to decrease in number, even to disappear before there has been any operative interference.

"It is also possible that in certain cases there is below the infected clot an obturating, noninfected clot which prevents the bacteria from entering the circulation. We can also imagine the possibility of there being an infected clot which completely closes the vessel. Another possible explanation is that in the course of the infection the blood may acquire a higher bac-

teriacidal power." No consideration of the possibility of the etiologic agent being one which lends itself to artificial cultivation with considerable difficulty is made.

CONCLUSIONS

It is remarkable how many cases of postanginal thrombophlebitis with sepsis have been described in association with gram-negative, anaerobic bacilli, and unfortunate how few of these bacilli have been reported with careful bacteriologic studies on their morphology, cultural characteristics, and pathogenicity.

In this paper a gram-negative, pleomorphic, hemophilic, hemolytic bacillus has been studied and described as the primary etiologic agent in a typical case of postanginal sepsis. This case is also presented with clinical and pathologic studies. This organism, as far as can be ascertained, after a careful search through the literature, is described for the first time in this paper.

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ASPIRATION OF BREAST CYSTS*

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A GENERATION ago two members of the New York Surgical Society contributed papers dealing with cystic conditions of the breast with special reference to treatment. William T. Bull¹ reported 39 cases of single cystic tumors and eight cases of general cystic disease which he treated mainly but not exclusively by aspiration. He said, "We have little evidence that the condition degenerates into cancer." Somewhat later Dr. Robert Abbe² reported 41 cases of cystic disease of the breast seen by him in eight years. Three-fourths were single cysts and one-fourth were multiple. He says, "There is probably no experience of the surgeon that yields him greater pleasure than to see the profound gratitude of patients who have come to him expecting a mammary amputation, to be told when the mammary cyst is aspirated that they are well." He followed his patients to the date of his publication and found none of them had developed cancer.

We have aspirated fully 50 cysts in the last 20 years. In several cases two or three aspirations have been performed at varying intervals and in one case there were at least four aspirations. In several cases two cysts have been aspirated at one sitting. Aspiration has never been adopted as an exclusive method of treating breast cysts, as is shown by the fact that during the same time 160 cases of benign breast conditions have been submitted to operations such as enucleations, partial or complete mastectomies.

So far as is known, no favorable comment was elicited by the papers of Bull and Abbe but they did bring forth some unfavorable criticism. In my series of cases there is no single instance in which I have gotten myself or patient into trouble as a result of submitting her to aspiration of breast cysts.

The aspiration method has been reserved for breast cysts in which one could be quite sure either from consideration of the history or digital examination that the mass was a cyst and to my knowledge an aspirating needle has never been introduced into a breast carcinoma. Perhaps the knowledge that the procedure is not looked upon favorably by surgeons has made me particularly cautious. After the cyst has been aspirated considerable time is always given to a discussion with the patient of the treatment of breast cysts. She is told that the method is not usually favored, that the cyst may refill and that the question of the advisability of operation has not been definitely settled.

At the conclusion of an aspiration one should be guided by the four following considerations:

* Read before the New York Surgical Society, October 23, 1935.

(1) If the content of the cyst is bloody, operation should be urged.

(2) If the cyst refills promptly, it will probably be wiser to resort to surgery. Very few of them do refill although other cysts may develop in the same or in the other breast. In one patient with a single cyst filling has not occurred in ten years. In another case the cyst refilled six years after an aspiration.

(3) The cyst wall is usually thin so that after complete aspiration the local area should be flat and there should be no remaining induration.

(4) The patient should be told to return if the cyst refills, and, under any circumstances, to return to the surgeon for reexamination within a month. Few will be found to have refilled and it is only by noting the point of entrance of the needle that one can identify the previous location of the cyst.

There seems a very strong prejudice on the part of surgeons against aspirating cysts. One is usually told that it is dangerous teaching. That it is would seem to be assumed from a fear that incompetent persons inexperienced in breast diagnosis and surgical treatment will be tempted to resort to this simple surgical procedure both in cases of cystic disease and also in the presence of lumps which they think may be cystic. If the precautions above mentioned are followed the dangers of the procedure will be very slight. None of the surgeons with whom I have discussed the subject admit that they ever resort to aspiration. On the other hand, Doctor Abbe states that it becomes the duty of every surgeon to test the nature of each doubtful hard tumor by an aspirating needle. With this I should not agree, preferring to treat every doubtful hard tumor by surgery.

The immediate relief that aspiration of a cyst gives to the frightened patient who has discovered a breast tumor is almost beyond belief. There are few occasions in a surgeon's career when he can give such immediate relief to mental suffering, establish a diagnosis and usually cure the patient.

It is, of course, this fear of cancer that keeps surgeons from aspirating cysts but it is often difficult to decide upon a method intermediate between aspiration of a cyst (or one excision to establish a diagnosis) and the removal of both breasts. A single partial mastectomy establishes a diagnosis of the condition of the portion of breast removed but does not prevent the development of cancer in the portion of breast retained, nor does it guarantee that carcinoma may not be present in other portions of that breast or in the opposite one.

Cheate's³ statement that 20 per cent of cancers of the breast are associated with cystic disease is much quoted but one should continue by quoting his next sentence, namely that, "The problem of the percentage of cystophorous, desquamative hyperplasia that end in carcinoma is much more difficult of calculation. The process begins as a desquamative epithelial hyperplasia which ends in the formation of cysts and occupies the decade of the late twenties and early thirty years of life. The desquamative process of the epithelium may not end in the formation of cysts but may pass into a state of epithelial neoplasia that is benign in character." Later on he says, "As a

general rule cysts containing clear fluid are not associated with malignant disease. Suspicion should at once be aroused if the contents of the cyst are in the slightest degree cloudy or contain blood or if the cyst wall is dense and bulky. An apparently single large cyst rarely contains carcinoma. Its epithelial lining is so degenerated that it is incapable of responding to the stimulus that produces neoplasia." Cheatle's statement that cancers of the breast show microscopic evidence of cystic disease may be correct but it is my experience that cancers of the breast are not associated with *clinically* recognizable chronic mastitis, that is, a nodular or cystic breast, in anything like 20 per cent of cases. Cancer usually appears if seen early as a single, fairly discreet nodule, whereas cystic disease is a more widespread condition. It may chiefly affect one lobule but very often involves all of one or both breasts.

Crile⁴ has stated that "if the condition—that is, cyst formation—is present in both breasts, malignant changes almost never develop." Ewing⁵ states that in 50 per cent of breasts removed for cystic disease which he has examined, precancerous changes or "miniature carcinomas" were present. If this interpretation of his microscopic pictures is correct, it seems remarkable that one can treat a considerable series of breast cysts by aspiration, observe them for a considerable period of years and not have a number of them return with carcinoma.

Rodman⁶ has studied the changes in breast tissues and says, "The amount of involution and evolution which a breast undergoes during its active life is great, no other organ being given to more epithelial unrest." Inasmuch as pathologists vary in their statements of the percentages of cancers of the breast in which hyperplastic disease is an accompaniment and give figures as far apart as 15 and 83 per cent, it may be that they are considering as abnormal hyperplasia some conditions which others would consider within the normal range of changes accompanying the menstrual cycle or early pregnancy.

Clinicians have been attempting to solve the problem from a different angle, employing a follow up of patients who have been submitted to partial or complete mastectomies for what has been considered chronic or cystic mastitis. Both Rodman⁶ and Pickhardt⁷ have changed their view considerably as a result of follow up of their clinical material. Pickhardt approached the subject with a preconception that the disease was of a precancerous nature. In studying the material from the Lenox Hill Hospital embracing 90 cases of cystic mastitis on which a follow up could be made, he says, "The clinical result as shown by a follow up of this series, even where only a local excision had been done, are so excellent and so remarkably free from cancer that the speaker has been convinced against his original inclination and must now feel that chronic cystic mastitis is a benign condition. If it is precancerous it shows that removal in that stage is sufficient to eradicate the cells which tend toward malignancy." The work of such clinicians as Campbell,⁸ Kilgore,⁹ Klingenstein,¹⁰ Pickhardt¹¹ and Rodman⁶ all tend in the same direction. Adair¹² is impressed with the importance of conditions

which produce stasis in the breast as causing first hyperplasia and then carcinoma. His evidence is based on the study of 200 consecutive cases of cancer of the breast with relation to pregnancies, miscarriage, sore nipple, etc., and has brought him to the conclusion that stagnation is of prime importance relative to the subsequent development of cancer. The frequency of these factors of stasis was very much greater in the cancer cases than in the 100 patients without cancer whom he used as controls.

Without referring to any one individual it may be said that the tendency of the past ten years based chiefly upon the clinical aspects of chronic mastitis has been to minimize the relation of carcinoma to cystic disease, and yet no paper which I have seen which considers the subject of treatment mentions aspiration of cysts, even to condemn it.

It is rather frequently stated, though on what authority is uncertain, that about 2 per cent of women of the cancer age will develop cancer of the breast. This about corresponds with my personal experience. One patient only, with cystic disease, has developed cancer. This patient was first seen with a cyst in the upper, outer quadrant of the left breast. It was aspirated of nearly clear fluid. One year later she developed a very small, quite superficial carcinoma about two inches from the location of the cyst. She was submitted to radical mastectomy and it is interesting to note that the cyst was still present but empty with its walls collapsed. There was no carcinoma reported as being present in the cyst. One cannot think that a partial mastectomy would have prevented the occurrence of the cancer.

Another case of cystic mastitis seems worthy of record. The patient, Mrs. G., was operated on three times at St. Luke's Hospital and on each occasion a segment of breast was removed. Each contained a cyst and each time the pathologic report was chronic mastitis. She later presented herself with a swelling obviously a cyst. She expected another operation but was relieved by having the cyst aspirated. Six months later she returned with a cyst in the other breast with reddened skin over its surface. This was also aspirated and there has been no further recurrence in a year. She might have been cured permanently on any one of these five occasions by amputation of both breasts or one might have added two more partial mastectomies, making five operations for a condition which is usually benign, and which had been proven so in her case. Anything less than bilateral mastectomy would not have prevented the recurrence of cysts nor the possibility of carcinoma. Of course there is no demonstration that she may not at some future time develop carcinoma. As she has just passed the menopause it seems quite likely that cysts will stop developing. However, it seems quite unlikely that many surgeons would have suggested bilateral mastectomy in the course of this patient's disease.

We practice surgery first to prolong life, second to restore or increase efficiency, and third, to add to the sum of human happiness. With the latter purpose in mind we aim to relieve mental suffering no less than physical

suffering and it requires only one experience with the aspiration of a breast cyst to assure one's self that the relief of mental suffering is profound.

CONCLUSIONS

Aspiration of breast cysts is not recommended as an exclusive method of treating them. It will often be considered wise to do one partial mastectomy to establish a diagnosis, after which if cysts appear aspiration may be employed in the treatment of masses which are definitely cystic. It is a procedure which is reasonably safe in the hands of any one competent to do any indicated breast operation. It has both diagnostic and therapeutic value. The fact that aspiration can be resorted to as frequently as in the present series without having a conspicuous development of cancer adds some evidence in favor of the generally benign character of cystic disease of the breast.

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DISCUSSION.—DR. JOHN E. JENNINGS (Brooklyn) stated that cysts of the breast are noted as masses lying within the organ, painless as a rule, by the patient or by the physician in a routine examination. The presence of the mass is cause for examination, the dread of cancer bringing the patient sooner or later to the surgeon. Various diagnostic procedures are then undertaken: inspection and palpation of the breast for appraisal of the fixation, retraction and character of the mass itself, transillumination, roentgenologic study, and aspiration, or, as it is now termed, biopsy.

Doctor Jennings, recalling his own experience with transillumination, related that having found the available lights inadequate, he had had made in 1920 a box with a 100 watt light behind a projecting tube containing a system of lenses. This, also, was inadequate. A year or so later, a similar apparatus was made to carry a 500 watt Mazda bulb behind lenses made of crystal to diminish the heat. An iris diaphragm was inserted in the system. Although the box was covered with asbestos it was not entirely heat proof, but was effective enough to reasonably evaluate transillumination of the breast. Experience in the use of an adequate and familiar instrument enables the observer to form opinions not too often wrong. Blood will show, in hematoma, in

papillary duct growths, in the large veins, and, with experience and the iris diaphragm, acute congestion in localized areas can be recognized. The distribution of large venous channels may indicate retractible pathology rather early in a heavy breast.

It is not always possible to distinguish between a cystic and a solid growth. This will depend as much on the thickening of the tissue surrounding the cyst as on the contents of the cyst itself which may be quite opaque. Doctor Jennings had had no experience with roentgenologic studies of the breast, but was concerned with the question as to what, if any, are the dangers of needling a suspicious tumor of the breast. It is admissible that if the mass is found to be a single cyst that disappears on aspiration, with the fluid not bloodstained and the smear innocent, great comfort to both patient and surgeon results. One does this occasionally, and all goes well. But it is less certain that as a general practice aspiration of a solid tumor is without some hazard. A negative result as to malignant tissue must be purely negative, leaving doubt just where it was before. A positive return should bring prompt action. There still remains, however, the effect of aspiration in disseminating the disease. It seems probable that one carcinoma will differ from another in the degree of local transplantability as well as in the ease with which venous invasion may be brought about.

DR. WILLIAM CRAWFORD WHITE (New York) called attention to the fact that large single cysts comprise but a very small proportion of the chronic cystic mastitis cases that are seen. It is difficult to differentiate localized chronic cystic mastitis consisting of small cysts of BB shot size, from early cancer. Very often they seem to be carcinoma when they are not, and vice versa. In a large proportion of cases one necessarily has to operate. If one believes in needle puncture biopsy, one can, of course, perhaps differentiate between malignancy and cysts, but even this may not be possible. In spite of all the insistence on the finding of chronic cystic mastitis associated with carcinoma, Doctor White could not agree that it is a precancerous condition. However, in reference to Doctor Mathews' quotation to the effect that, if one saw multiple nodules, especially in both breasts, he could rest assured that it was chronic cystic mastitis, Doctor White felt great care should be exercised especially if any nodule feels hard. In the series at Roosevelt Hospital, if partial mastectomy had been harmful, more cases of carcinoma should have developed subsequently. In a series of 590 cancers of the breast only one case of chronic cystic mastitis subsequently developed carcinoma in the same breast. She had had a partial mastectomy for chronic cystic mastitis in 1923. In 1929, she developed a colloid carcinoma of the same breast. It was felt there was no relationship between the two.

DR. FRANK E. ADAIR (New York) agreed with Doctor Mathews, especially with the main implication of his paper, namely, that simple cysts can and should be treated by aspiration and not by surgical extirpation. It becomes necessary many times to excise locally the breast cyst, in order to be certain of the exact pathology. However, there are times when the diagnosis of a simple cyst is quite definite; and in such an instance the diagnosis can be confirmed and the cyst usually cured by the simplest procedure—an aspiration. A cyst when small (1 cm. in diameter or less) is difficult to diagnose because it is so tense with the intracystic fluid that palpation gives one the impression of its being a firm tumor such as a fibro-adenoma or area of localized mastitis. When the cyst becomes larger it becomes easier to diagnose because fluctuation can be elicited, the edges are sharper, and, due to expansion, it appears to be nearer the palpating fingers.

Technic.—To aspirate a cyst one should take a small sized hypodermic needle and infiltrate the skin over the dome of the cyst with a small wheal of 1 per cent novocaine. In order to keep the larger needle of the Record or Luer syringe from being gripped too tightly by the integument, it is better to make a fine stab wound just through the skin, with a narrow sharp-pointed blade. An 18 gauge needle is then inserted into the cyst. It is important that the needle should not be gripped too tightly by the skin otherwise one will not get the sensation of the needle point penetrating the cyst wall.

Most men are now agreed that carcinoma rarely occurs in a breast containing single or multiple simple cysts, and agree that the original studies of Bloodgood in which he stated that carcinoma never develops in the breast which contains a blue domed cyst, is not true. Carcinoma does, as a rarity, occur in such a breast, but in our series of simple blue domed cysts, the presence of carcinoma occurred in slightly less than 2 per cent. Bloodgood was, therefore, almost correct. My own studies show in those rare cases in which a carcinoma developed in a breast containing the blue domed cyst, that the carcinoma was not an integral part of the cyst wall, but developed in the intercystic portion of the breast. In general the breast containing the simple cyst is usually free of carcinoma.

In looking over the records of 664 breast cases coming to Doctor Adair's service at Memorial Hospital in 1934, it was found that there were 8 per cent of instances of solitary breast cysts.

In Doctor Adair's experience cysts of the breast contain fluid of several types: (1) Straw colored fluid, (2) muddy colored fluid, (3) opalescent colored fluid, (4) milky fluid or heavy, creamy fluid, (5) infected, straw colored fluid with floating flocculi, and (6) bloody fluid.

In the cases of clear, straw colored fluid and the opalescent fluid, a single aspiration cures in about 85 per cent of the cases. It always amazes me that the cyst does not promptly refill, but it usually does not. The cyst with the muddy colored fluid is not cured by simple aspiration in as high a proportion of instances. The cyst containing the flocculi is infected and always refills no matter how many times it is aspirated. This interesting cyst is the type that frequently shows skin attachment, and it is occasionally on account of this sign that it is mistaken for carcinoma. The bloody cyst should always be removed as it is cancerous in about 48 per cent of the cases. After its removal and careful study, it frequently becomes necessary to proceed with a radical mastectomy.

Solitary cysts of the breast occur in the late thirties and in the forties. In only one instance of 52 cases of last year did the solitary cyst manifest itself after 50 years of age. In other words, most of the cystic changes take place about the time of the menopause, which is a diagnostic point of importance. In the diagnosis of cysts, one must always consider the pain attribute. Pains are intensified at the time of the menses and regress after their cessation. Cysts occasionally appear with one period and completely disappear before the next menstrual phase. Cysts have a direct relationship to ovarian function. The concomitant state of cysts of the ovary and of the breast has often been noted.

In the case of multiple bilateral breast cysts, it is frequently possible to carry the patient through the period of the menopause (possibly for a year and a half) by aspirating those cysts which are most painful. It may be necessary to repeat this procedure three or four months later, but during this time the cysts gradually become smaller as the mammary tissue atrophies. This is the therapy of choice; otherwise a bilateral mastectomy would become necessary; which is most undesirable.

CHRONIC PROGRESSIVE POSTOPERATIVE GANGRENE OF THE ABDOMINAL WALL*

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GANGRENE of the abdominal wall is an unusual postoperative complication. The object of this paper is to report a case of chronic progressive gangrene of the skin and subcutaneous tissues of the abdominal wall with special reference to the bacteriology of this particular infection, its differential diagnosis and the treatment indicated for its control.

CASE REPORT

Mrs. C., aged 57, was admitted to the St. Joseph's Hospital, Tacoma, February 5, 1935, with a diagnosis of acute appendicitis. She was operated upon immediately. The appendix was retrocecal and showed beginning gangrene. The wound was closed in layers with catgut and three dermal tension sutures. The abdominal cavity was drained with a split rubber tube which was removed on the sixth day. The patient made a normal but rather slow convalescence. She was discharged from the hospital on the nineteenth day following the operation. With the exception of slight drainage from the lower angle, the wound was closed. Some redness persisted at the site of the tension sutures.

Soon after, however, the wound began to break down rapidly, and in spite of the fact that the drainage from the depths of the wound gradually ceased, there developed a progressive spreading gangrenous ulceration of the skin and subcutaneous tissues. On April 9, 17 days after the patient was discharged from the hospital, the abdominal wall presented the picture shown in Fig. 1. The wound edges had separated and extensive sloughing of the skin and subcutaneous tissues had taken place. The free edges of the gangrenous area were undermined, and surrounding the necrotic border, a zone of advance showed about 3 cm. in width, slightly raised near the gangrenous zone, cherry red in color, and gradually fading into normal tissue. *The entire area was excruciatingly sensitive.*

Free incisions, for drainage, and repeated excisions of the gangrenous slough over a period of about two months were performed. Various applications including merthiolate, hydrogen peroxide, permanganate and Dakin's solution failed to control the slowly advancing ulceration. The patient was given a blood transfusion and antistreptococcus serum without apparent benefit. Fig. 2 shows the area involved on April 29, 1935, at which time the patient was readmitted to the hospital. Her physical condition was remarkably good, considering the extent and apparent virulence of the infection. Her morale, however, was badly shaken due to the extreme sensitiveness of the abdominal wall, to pain, and to her failure to improve. The skin was so sensitive that most of the dressings were done under Evipal anesthesia.

The first bacteriologic cultures which were taken upon her readmittance to the hospital showed an enormous number of hemolytic streptococci with an occasional colony of staphylococci and *B. coli*. There was no growth obtained by anaerobic culture. These cultures were taken from the necrotic tissue immediately adjacent to the large ulcer, but none was taken from the unbroken zone of advance. The anaerobic cultures

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were made on brain heart infusion blood agar plates, with the use of the Spray anaerobic culture dish." The bacteriologic findings led to the conclusion that we were probably dealing with a hemolytic streptococcal infection.

The clinical resemblance of this case to those described by Dr. Frank L. Meleney¹ of New York induced us to forward to him a clinical history and photograph of the lesion. He suggested that it was the same type which he had described as a progressive postoperative bacterial synergistic ulcer, and advised further bacteriologic study with especial attention to the zone of advance. Following these suggestions, further cultures were taken. From the necrotic tissue, a hemolytic staphylococcus was obtained. Cultures taken from a piece of tissue excised from the red area adjacent to the normal skin gave, by the anaerobic technic described, a growth of non-hemolytic anaerobic streptococcus in pure culture. There was no growth aerobically from this section of tissue. After two generations, this non-hemolytic anaerobic streptococcus showed slight aerobic growth on Loeffler's blood serum. This corresponds culturally to the organisms which

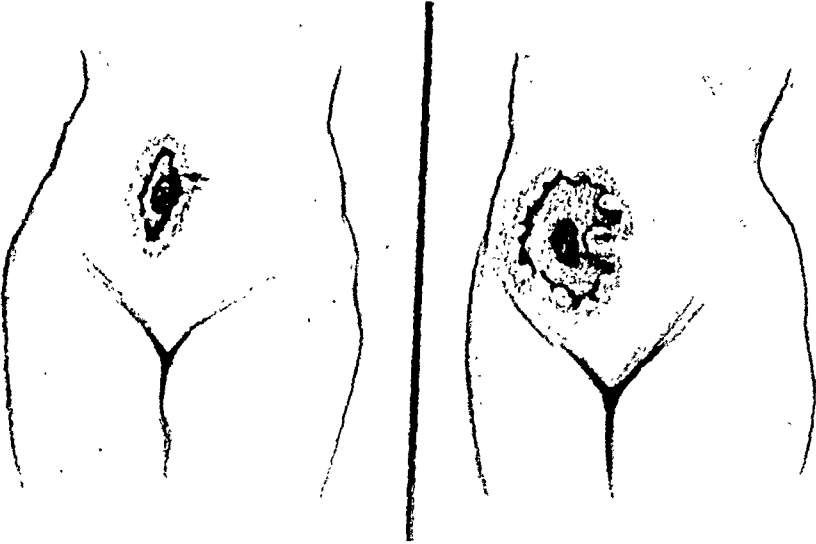


FIG. 1.—The wound began to break down on 19th day following operation. Illustration shows extent of ulceration April 9, 1935, two weeks later.

FIG. 2.—Area involved April 29, 1935. Part of slough has been cut away.

Dr. Meleney had found in similar cases and which he had predicted would be found in this case. He has designated this as "micro-aerophilic."^{1, 2, 3} At this time more radical treatment was employed; not only was the sloughing tissue removed, but as far as possible all infected tissue was excised, with the scalpel, well out to the periphery of the zone of advance. Following radical excision, the wound was dressed daily with gauze saturated with a suspension of zinc peroxide in sterile water, which was covered with vaselined gauze to prevent drying.

Fig. 3 shows the abdominal wall at nearly the maximum advance. A slightly undermined area of necrosis is shown around most of the border. Fig. 4, taken about ten days later, shows the infection nearly under control. This photograph shows some new areas of skin beginning to spread from centers which have survived the necrotic process. The day this photograph was taken the last excision of tissue at the periphery was performed, and at the same time a number of Thiersch and pinch grafts were placed over the denuded area. Following the radical excision, the progress of the ulcer was definitely stopped (Fig. 5). Later, further skin grafting was done. The denuded area closed in quite rapidly until nearly covered. The patient then suffered a temporary period of retrogression, followed by gradual recovery and finally complete epithelization.

Doctor Meleney, who has made an extensive clinical and bacteriologic

GANGRENE OF ABDOMINAL WALL

Fig. 3.—Abdominal wall shown at nearly maximum advance. Area of necrosis shown especially at upper border.



Fig. 4.—Infection nearly under control. Small areas of skin shown which have survived necrotic process.



Fig. 5.—Healing. Some skin grafts placed.



study of wound infections, has described several different types of superficial infectious gangrene.³ Examples of the acute types are "gas gangrene" and "hemolytic streptococcic gangrene." Each of these conditions is caused primarily by a single bacterial species. Each has its own clinical picture, but they are alike in that both spread rapidly without a definite line of demarcation but with extreme necrosis and undermining of skin and subcutaneous tissues. Neither produces marked local pain or sensitiveness, but both produce extreme prostration and result in a high mortality, and in the case of streptococcic gangrene early positive blood cultures with metastasis are usually found.

The case described in this report, in contrast to the above mentioned types, represents one of the more chronic forms of infectious gangrene. It has a distinct and very sharply defined clinical picture. It is a spreading ulcer with a gangrenous border without undermining of normal tissue or the production of sinuses. It is characterized by slow but relentless progress, by extreme sensitiveness of the area involved and by the lack of severe systemic symptoms.

A number of cases of progressive gangrene with this clinical picture have been described in the literature.^{4, 5, 6, 7, 8, 13, 14} Brewer and Meleney described two, and subsequently Meleney has described four of them,^{2, 3} and has been able to culture from all of them, what he considers to be the essential organism, namely a nonhemolytic micro-aerophylic streptococcus which is found, by anaerobic methods, in pure culture in the zone of advance, but in the gangrenous area this organism is associated with a staphylococcus aureus. On the basis of these findings and animal experiments with combinations of these organisms, he has further concluded that this particular type of progressive gangrene is produced by a symbiotic or synergistic action between these two organisms. In this case, the organisms which we recovered corresponded morphologically and culturally to those described by Meleney. Furthermore, animal inoculations made by the Porro Biological Laboratories in Tacoma confirm his conclusion that this condition is produced not by a single organism but by a symbiotic or synergistic action between the two organisms—neither of which alone may be virulent.

Four guinea-pigs were given subcutaneous inoculations. The hemolytic streptococcus first obtained from the area of slough when injected alone produced an abscess which cleared up. The hemolytic staphylococcus obtained later from the area of slough when injected alone also produced a small abscess which cleared up. The nonhemolytic streptococcus from the zone of advance produced alone a small abscess. In contrast, the hemolytic staphylococcus and nonhemolytic streptococcus injected together produced a large spreading ulcer of the skin and early death of the guinea pig.

This disease must not be confused with another condition which the same author has described,¹² namely, a chronic ulceration which is nongangrenous but which is characterized by extreme undermining of the skin and formation of deep sinuses. The organism which has been found to be most

closely identified with this infection is a micro-aerophylic (facultative aerobic) hemolytic streptococcus, as contrasted with the nonhemolytic organism found in the lesion described above.

COMMENT.—This case was controlled by wide excision with the scalpel. The use of the hot cautery or radio-knife, however, is advocated as preferable to the scalpel by most clinicians who have reported cases of this type.^{7, 8, 10, 11, 15} Horsley¹⁶ states that in no instance should the scalpel be used.

It is probable that if radical excision is performed, the special dressing employed is of minor importance in controlling the infection. The zinc peroxide dressing was employed in this instance upon the suggestion of Meleney.¹² Zinc peroxide applied in suspension is believed to give off nascent oxygen over a period of several hours, and probably either by this action or by a direct peroxide action has the power of inhibiting the growth of anaerobic or micro-aerophylic organisms.

CONCLUSIONS

Experience in this case, together with a review of the literature, seems to justify the following conclusions.

This condition represents a rather rare instance of chronic infectious, superficial, progressive gangrene which belongs to a very definite clinical group and which should be recognized clinically. It is differentiated clinically from other types of superficial gangrene by its slow and relentless progression, its severe local symptoms and the absence of severe systemic symptoms.

It is characterized bacteriologically by the fact that in contrast to the other types described, it is produced, not by a single virulent germ, but by two organisms, neither of which alone may be virulent, but which in combination produce a virulent infection. It is important that the nature of this infection be recognized early, that conservative treatment be discarded, and that wide and radical excision be employed promptly.

As far as the author is aware, this is the first time that the bacteriologic findings described by Meleney have been confirmed.

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THE ELECTIVE TRANSVERSE ABDOMINAL INCISION

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ANY attempt to break down a time honored tradition is always met with opposition, sometimes justified, sometimes not. This is especially true in regard to well established procedures in medicine and surgery. Yet with the wide open mind possessed by our profession there is that tendency toward improvement which prompts us to admit the value of something which we have been reluctant to adopt. This statement applies especially in the matter of abdominal incisions. The technic of the transverse abdominal incision is not new and has its disadvantages as well as many advantages. Contrary to the prevailing opinion, it has sound anatomic and physiologic bases, and in resurrecting this item of surgical technic for discussion, we wish to point out these anatomic considerations together with the indications and contraindications for the use of this type of incision. In view of the many good and detailed reports, it is our intention to confine ourselves to the salient features of the anatomy, physiology and technic, and to give further consideration to the experiences of other surgeons.

The object of any abdominal incision is threefold, namely: (1) adequate exposure; (2) secure and reliable closure, and (3) prevention of hernia. Thus we feel that this incision fulfills, under proper indications, these requirements better than any other.

We were led to adopt the use of the transverse incision in the upper abdomen through the good reports of others, and after searching the literature we were convinced that this was a rational procedure. Most of the articles dealt with the decrease of postoperative herniae following this incision, and this perhaps was the strongest factor in inducing us to employ it. Furthermore, in the use of the vertical incision, the first procedure after opening the peritoneal cavity is usually its conversion into a transverse incision by lateral retraction, sometimes such great force being necessary, for the proper exposure, as to traumatize the structures of the abdominal wall.

Historical Résumé.—It is not certain who was first to use the transverse incision in surgery of the abdomen. Its evolution, however, is quite interesting. It is known that it was used by Baudelocque for cesarean section prior to 1847. Trendelenburg had occasion to use it in 1882 in surgery in the urinary bladder. Kustner, in 1896, proposed transverse incisions at the pubic line for pelvic operations, primarily for cosmetic reasons. In the same year J. W. Elliott of Boston made a transverse incision in the skin beginning at the edge of the rectus, as a modification of McBurney's incision. Pfannenstiël began in 1898 and reported in 1900 his suprasymphyseal transverse incision of the skin and fascia with median division of the deeper tissues for operation upon

the uterus and adnexa. This incision was being used at the same time by Stimson of New York and Hartmann of Paris independently, and was reported later.

To A. E. Maylard, Glasgow, Scotland, in 1898, is conceded the priority for the use of the transverse incision through the complete thickness of the upper abdominal wall. A word might be said about his first case. He had performed a gastric operation through a median incision supplemented by an incomplete right transverse extension. Due to internal hemorrhage reoperation was necessitated the same day. He states, "The wound healed with a result which showed a perfectly secure and non-yielding cicatrix of the transverse incision but marked tendency to hernial protrusion of the median one." This to Maylard seemed contrary to expectation but when reasoned anatomically, seemed logical. This case led him to further work and in 1907 he reported 45 operations for pelvic work, all through complete transverse incisions above the semilunar fold of Douglas.

In 1906, Boechmann, of St. Paul, Minn., began the use of the transverse abdominal incision in all types of abdominal surgery including extraperitoneal as well as intraperitoneal operations. He was under the impression, until he wrote his very complete paper in 1910, that this type of incision was original with him. At the time of the publication of his paper in 1910, he reported 400 cases in which the incision had been employed, more than 300 of which were in the lower abdomen, with the end-result of one hernia.

Boechmann's work was watched with favor by Hasselgrave, of St. Paul, Minn., who began its use in 1907, and reported, in December, 1910, 128 cases of operations above and below the umbilicus, on all types of abdominal surgery, without any hernia. He was particularly impressed with the good end-results following drainage in infected cases.

In 1910, Sprengel, of Germany, introduced into Europe and strongly advised the use of the transverse incision in the upper abdomen. His work was given impetus by Bakes of Germany the following year when he reported 297 cases with no postoperative herniae.

Since that time papers have intermittently appeared in this country and abroad favoring the use of this incision. Among those advocating this technic in later years are Meyer, 1915; Moschowitz, 1916; Farr, 1917; Quain, 1917; Moore, 1922; and Bartlett, 1933.

Anatomy and Physiology.—The anatomy of the region concerned is not complex. Since the skin is the first structure incised, it is sufficient to mention and observe that the skin cleavage is transverse to the long axis of the body. The muscles concerned are eight, the six flat muscles, splinted vertically by the two recti abdomini. The fibers of these flat muscles are transverse anteriorly, as their aponeuroses converge to ensheath the recti, and are inserted into the linea alba opposite each other.

The rectus sheath above the semilunar fold of Douglas is a firm and important anatomic structure. It is formed anteriorly by the aponeurosis of the external oblique and the anterior lamellae of the aponeurosis of the internal oblique, and posteriorly by the posterior lamellae of the internal oblique

and the aponeurosis of the transverse abdominus. The fibers of all of these structures course in a transverse direction. Therefore, in closure of the transverse incision the sutures are inserted at right angles to the fibers and not parallel to their long axes.

The recti are crossed by three fibrous bands, the tendinous inscriptions (transverse lines) usually situated at the umbilicus, at the inferior border of the xiphoid process and midway between. These bands extend halfway through the muscle and give to it a segmented effect and are intimately adherent to the anterior sheath. They are constant and are of value, first, as a landmark in this incision (since the seventh, eighth and ninth nerves as a rule enter the rectus sheath immediately below them [Blair]), second, they prevent the retraction of the several ends of the recti, and third, they form a double anchorage in closure.

Laterally where the flat muscles converge to ensheath the recti, their fibers run in their normal obliquities, which should be remembered when the incision has to be lengthened, in which case the fibers are separated in their normal planes.

The parietal motor nerve supply to this region is derived from the anterior divisions of the seventh, eighth, ninth and rarely a terminal branch of the tenth thoracic nerves, the so called thoraco-abdominal intercostal nerves. They course obliquely from their origins between the intercostal muscles to the midaxillary line where their course becomes transverse. Then they pass from behind the costal cartilages, between the internal oblique and transverse abdominus to enter the rectus sheath. The main trunk is posterior to the rectus muscle sending branches to it and terminating as the anterior cutaneous branch which pierces the rectus sheath supplying the skin. Midway in their course they give rise to the lateral cutaneous nerves which pierce the external intercostal and oblique muscles supplying the skin. It is thus noted that the main nerve and even its minute branches course in a transverse direction in the operative site. The position of these three nerves is rarely changed (Blair). It is needless to mention the importance of the maintenance of nerve supply to any structure.

The blood supply to this region is derived chiefly from the superior and inferior epigastric arteries. Here the incision cuts at right angles to the long axis of the vessels but the anastomosis on the rectus sheath is so profuse that their severance is negligible, as may be seen in any authoritative dissection.

The physiologic action of the abdominal muscles depends upon the fixation of the thorax, pelvis, and vertebral column; for example, if both pelvis and thorax are fixed, the muscles compress the abdominal cavity, in which case they are materially assisted by the descent of the diaphragm. If the pelvis and vertebral column are fixed, the muscles compress the lower thorax, assisting in expiration, *etc.* If the pelvis alone is fixed, the thorax is bent directly forward. If the thorax alone is fixed, the pelvis is brought upward. The recti acting above flex the pelvis on the vertebral column, and if below flex the thorax on the vertebral column.

When the flat muscles on both sides contract they compress the abdomen,

their power being delivered through the recti sheaths to the midline in the direction of the long axis of their fibers, so that there is the normal tendency of a vertical incision to be pulled apart, whereas coughing, sneezing, straining, *etc.*, would tend to relax and approximate the wound in a transverse incision.

Sloan, in his paper, states that there is 30 times more pull in vertical closures than in the transverse. He has proven experimentally in the operating room that in vertical incisions there is from 20 to 50 pounds' pull on the posterior aponeurosis alone in lightly anesthetized patients. This work has been confirmed by others.

Therefore postoperative patients, in whom the vertical incisions have been used, will, because of pain, splint their incisions by inhibiting normal thoracic and abdominal respirations, thus favoring atelectasis and pulmonary hypostasis.

Operative Technic.—To those who have never employed the transverse incision, it might seem cumbersome and awkward, and that much time is spent in opening and closing the abdomen. However, repetition and familiarity with the procedure will overcome this.

The level at which the incision is made depends on the pathology present, and we advise the procedure only in elective cases with clear cut pathology. Thus if roentgenologic examination shows a pathologic high-riding stomach, diseased gallbladder, or colon carcinoma, *etc.*, the incision is made accordingly at the indicated level. However, if emergency laparotomy is indicated, a line one inch above the umbilicus is chosen.

A transverse incision is made through the skin and superficial fascia, down to the recti sheaths at the indicated level. The sheath is bared a half inch to each side of the skin incision, keeping in mind subsequent closure. The wound is walled off with sterile skin towels. The tendinous inscriptions are identified, and if convenient, the recti sheaths are opened transversely just above them. The recti muscles are then severed through their entire thickness to the posterior aponeurosis, care being taken not to cut suddenly into the peritoneal cavity at the midline, though if such were to happen the abdominal viscera are, as a rule, protected at this vulnerable point by the falciform ligament of the liver. At this stage, there may be variable bleeding from the recti muscles, at times moderately profuse, needing ligation, other times negligible. The peritoneal cavity is then opened by any of the accepted methods, following which the falciform ligament must be severed between clamps and then ligated. Usually the stomach and transverse colon present themselves, depending on the level of the incision. There is not that tendency of automatic evisceration as in the vertical incision, and if the above are not the seat of pathology they are easily packed off, requiring less gauze than usual. If the gallbladder elevator is employed, there is good exposure with free access to the gallbladder, biliary ducts, stomach, pylorus, duodenum, pancreas and transverse colon.

In closure, a breaking type of operating table is of distinct advantage, for if the patient is "jack-knifed" slightly the wound margins fall together easily, and respirations do not disturb their approximation. The falciform

ligament is united at times separately, and at times with the continuous peritoneal suture. The peritoneum, including the posterior aponeurosis, is closed with a continuous suture and it will be found that there is extremely little tension on the suture line. In addition, the sutures are going in at right angles to the aponeurotic fibers, so there is no tearing. If tension

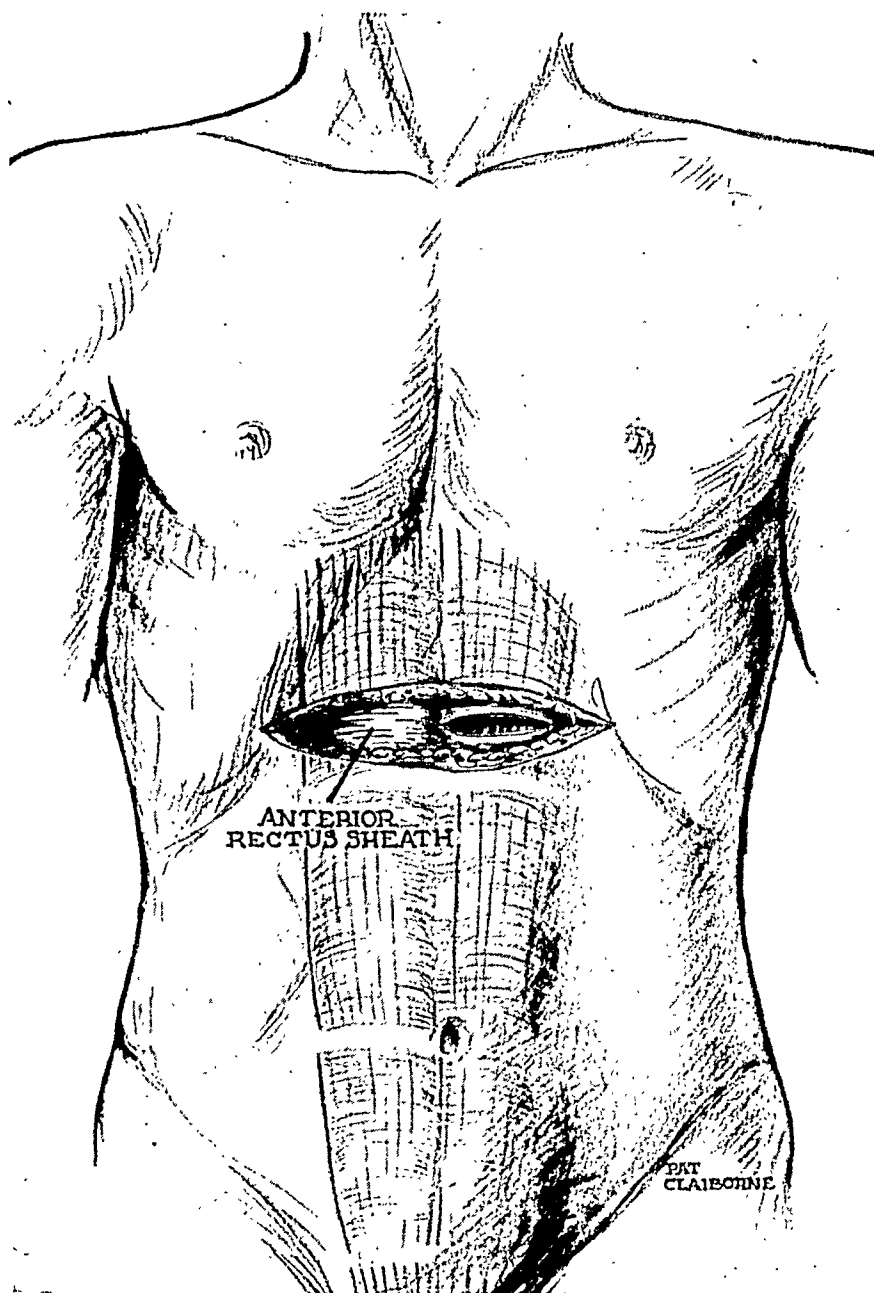


FIG. 1.—Illustrates the level and line of incision approximately midway between xiphoid and umbilicus immediately above the second tendinous inscription.

sutures are elected they are inserted at this point, although we have not found them necessary except in contaminated cases. The recti muscles are occasionally approximated with several mattress sutures of No. 0 catgut, but their repair, as a rule, is ignored. The anterior sheaths of the recti are then closed with interrupted or figure of eight silk sutures, after which the skin is closed with interrupted silk.

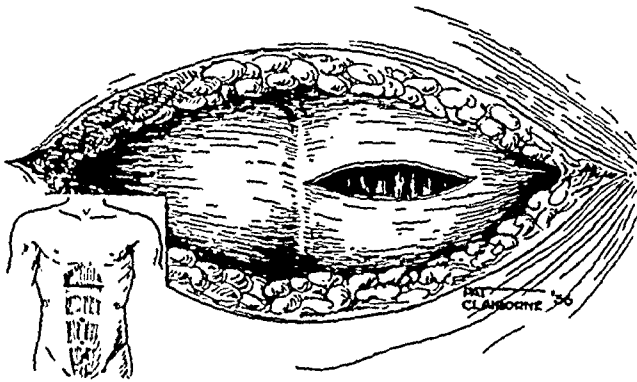


FIG. 2.—The incision made through the skin and superficial fascia. The fascia cleaned, and the left anterior rectus sheath incised. The transverse fibers of the anterior rectus sheath and the vertical fibers of the muscle are sketched. Inset shows the line of incision through the rectus sheath and muscle.

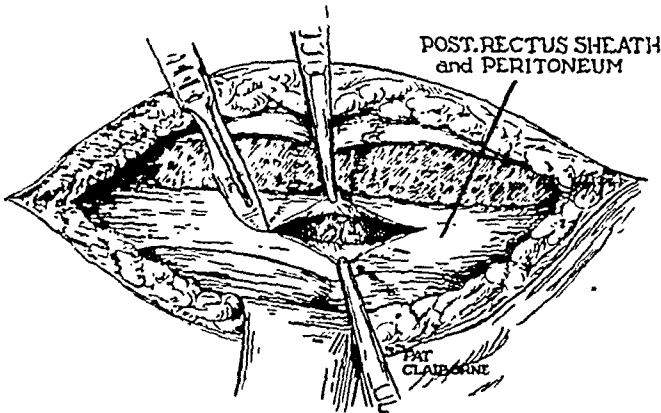


FIG. 3.—Both recti muscles severed, bleeding controlled, the posterior rectus sheath with peritoneum being opened in the midline. The falciform ligament of the liver presents.

CONTINUOUS
NO. 1 CHROMIC

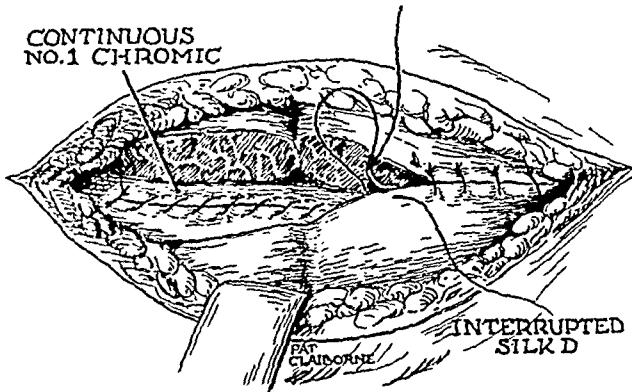


FIG. 4.—Peritoneum and posterior rectus sheath, together, closed with a continuous suture of No. 1 chromic catgut. Left anterior rectus sheath being closed with interrupted D silk sutures.

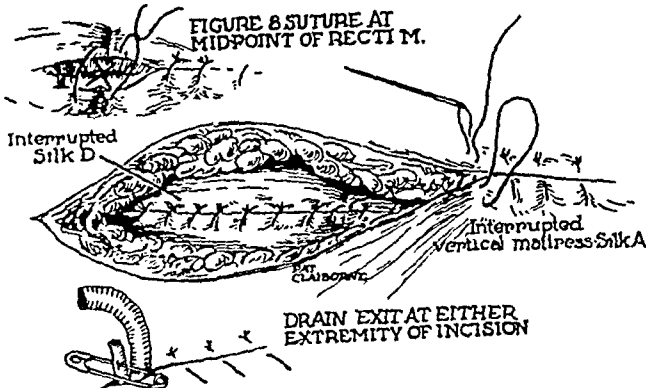


FIG. 5.—Both anterior sheaths closed with interrupted sutures of D silk. Skin and superficial fascia being closed with interrupted vertical mattress sutures of A silk. (Inset above) —Insertion of a figure of 8 silk suture at the midpoint of the recti, securing all four points on the two sheaths. (Inset below) —Illustrated exits of drains at the extremity of the wound. In this instance a cholecystostomy tube and a small rubber subhepatic drain is shown.

When drainage is necessary, the drains are placed in one or the other extremity of the incision. (At this clinic, almost without exception, all cholecystectomies are drained.) Thus the drainage tract is straight, and the drains remain secure without bending or tension. When they are finally removed, the wound heals rapidly without thickening of the scar. If, for any reason, contamination of the abdominal wall is feared, a gutta-percha or a split Dakin tube can be placed under the recti muscles and emerge at either extremity of the incision. We refer those interested in a further pursuit of this problem to the papers of Moschowitz, Hasselgrave, Meyer, and Moore, who testify to the excellent end-results obtained, in drained and postoperatively infected cases, using this incision.

In reviewing the literature we find there are many writers who have used the transverse incision and advocate it over the vertical. Some are over-enthusiastic in proposing it in all types of abdominal surgery, others advising it only in elective cases. Too few, however, have accurately stated the number of cases in which it was employed. Some of its strongest supporters have not reported any cases. In the articles reviewed, only 1,763 cases were collected in which the transverse incision was used above the semilunar fold of Douglas (Table I).

TABLE I
COLLECTED CASES IN WHICH UPPER ABDOMINAL
TRANSVERSE INCISION WAS USED

Maylard.....	45
Boechmann.....	400
Hasselgrave.....	128
Bakes.....	297
Moschowitz.....	97
Quain.....	500
Meyer.....	8
Farr.....	150
Jones and McClure.....	125
Bartlett and Bartlett.....	13
	<hr/>
	1,763

Doubtless the incision has been used many more times than has been recorded. Almost without exception all writers stress the decreased occurrence of postoperative ventral hernia. However, even in the above reported cases the postoperative study is poor and incomplete in this respect.

Statistical Résumé.—The writers' experience is limited, but in the past 18 months we have employed the transverse incision in 73 cases. The ages of the patients varied from four weeks to 84 years. It has been used on both men and women, white and colored. Some patients had had previous operations, some were obese, some thin and others muscular, so that it was used on almost every type of patient. One case particularly deserves mention. A colored man was operated upon for a perforating gastric ulcer at which time a gastrorrhaphy together with a sliding omental graft and pos-

terior gastro-enterostomy were performed. The abdomen was closed without drainage. Six days postoperative he developed a wound infection which involved both aponeuroses of the recti; it increased in severity until an abscess formed which dissected its way down the right side of the abdomen and pointed in the scrotum. Drainage and irrigation were instituted, and after a rather long convalescence the patient was discharged, recti healed and the wound firm. He has been examined repeatedly and at the end of 12 months the recti are still firmly united but there is a fusiform ventral hernia presenting in the midline.

The 73 cases that were operated upon are divided as follows: gallbladder, 32; stomach, 20; duodenum, 7; colon, pancreas, spleen, and adhesions making up the remaining 14. Among these cases 12 appendectomies were performed at the same time. Forty-one of the 73 were drained.

There have been 13 deaths in this group of patients. Carcinomatosis, 8; cardiac failure, 2; aspiration pneumonia, 2; and pulmonary embolus, 1.

In our follow up study there has been one hernia found and five patients we were unable to contact.

Advantages and Disadvantages.—Continuing the brief discussion above we shall now specifically recapitulate the advantages and disadvantages of this procedure to the patient and the surgeon.

Advantages to the Patient:

- (1) Less anesthetic necessary, for when the recti are severed there is no rigidity to overcome.
- (2) Greater protection and less shock is offered, since the intestines are retained in their normal cavity, necessitating neither handling nor exposure.
- (3) Less gauze packing is necessary.
- (4) Less wound reaction, due to elimination of forceful retraction.
- (5) Firmer aponeurotic union, therefore less postoperative hernia.
- (6) Less pain, as postoperative movements of vomiting, coughing, straining, *etc.*, tend to approximate, rather than pull on, the suture line.
- (7) Less pulmonary complications (Jones and McClure), since with less splinting for pain there are freer thoracic and abdominal excursions, thus less pulmonary hypostasis and atelectasis.
- (8) Cosmetic result is better, and even in drained cases there is no stellate scar resulting.

Advantages to the Operator:

- (1) Anatomically correct—the incision is in line with the skin, and aponeuroses of the recti. It also leaves the nerves intact, thus decreasing risk of hernia.
- (2) Physiologically correct—not only in closure, but postoperatively, respirations tend to approximate the wound margins rather than pull them apart.

- (3) Incision gives excellent exposure.
- (4) Retractors rarely necessary.
- (5) The incision facilitates easy delivery and replacement of viscera.
- (6) Incision gives easy, secure, and reliable closure, in that there is no tendency to peritoneal tearing.
Muscle fibers cut at right angles heal more rapidly (Moore).
Sutures are inserted at right angles to the recti aponeuroses, not parallel.
Tension sutures rarely necessary.
- (7) The incision facilitates direct and comfortable drainage, without tension on the drain and with minimum risk of subsequent herniation.
- (8) There is decreased tendency to fascial slough over vertical incision (Meyer).
- (9) There is diminution of cicatrix when reopened (Moschowitz).
- (10) There is better behavior and there are better end-results in presence of infection (Meyer, Moschowitz, Hasselgrave).

Disadvantages:

- (1) Anatomically—the incision cuts across the recti muscles. To refute this disadvantage we refer to Moore's article, in which he discussed, microscopically, the rapidly healing vascular edges of the recti muscles; but a still better reference that these severed recti heal rapidly, securely, and reliably will be gained by actual experience in the use of this incision and repeated examinations of the patients postoperatively.
- (2) Bleeding—as stated above is variable and in some cases more time is consumed in ligation than in vertical incisions, at other times considerably less. There is, however, no permanent damage to blood supply.
- (3) We do not find or claim this as the ideal incision for free access to all of the abdominal viscera.

CONCLUSIONS

- (1) The transverse upper abdominal incision has rational anatomic and physiologic bases.
- (2) It eliminates extensive packing off of surrounding viscera.
- (3) It reduces the handling of viscera to a minimum.
- (4) Postoperative discomfort in the form of gas pains is rare.
- (5) The incidence of postoperative herniae is greatly reduced.
- (6) In our experience pulmonary complications have been less frequent.
- (7) We believe the transverse abdominal incision is ideal in elective cases of clear cut pathologic conditions in the upper abdomen, giving us most satisfactory exposure of the diseased process and an easy, secure, and reliable closure of the abdominal wall.

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DISCUSSION OF THE PAPERS OF DOCTORS SANDERS AND LYNN

DR. ALBERT O. SINGLETON (Galveston, Tex.).—I find quite a bit of comfort in the fact that these two papers have been read upon the anatomy of incisions in the abdominal wall, and have spoken repeatedly upon the subject.

I have used the upper abdominal incision as described by Doctor Sloan, with some modification, since 1927, and have used it exclusively, except in those patients who have previously had vertical incisions made, and as I remember on one other patient, who developed a cough which caused his wound to open, necessitating resuturing. I have found more comfort and satisfaction in its use than probably any one problem in surgery which I have encountered.

The real virtue of the incision is due to the fact that fascia is the true holding material of the abdominal wall, and wherever there is need for strength in the abdominal wall, there we find the greatest amount of fascia. The fascial tissue generally is the tendinous continuation of the transversalis and internal oblique muscles; they meet in the linea alba, and the fasciae are recognized as the anterior and posterior sheaths of the recti muscles. The fibers of these fascial structures course transversely, the direction of the greatest strain; therefore, it is evident that these fascial structures should not be cut across the direction of their fibers, which is done if the incision is made vertically. I feel that we should become fascia conscious, so that we should have the greatest possible strength in the abdominal wall when we finish the operation. We follow this principle ordinarily in the McBurney

type of incision, also in the common method of repairing umbilical hernia, by overlapping the fascia in an up and down manner, rather than transversely. If we measure the pull upon the posterior sheath of the rectus muscles, in a transverse direction, we will find that it is tremendous. Since the internal oblique and transversalis are respiratory muscles, in the act of coughing or vomiting this pull is greatly increased and occasionally it does not hold if sutured in a vertical direction. Therefore, we believe that these fascial structures should never be cut vertically if it can be avoided.

Extensive dissection of the skin incision is generally repulsive to the average surgeon, when he desires to get into the abdomen quickly, and often he is too impatient to take the time to make the proper incision. We can safely say that the time for the entire operation is not longer, because the closure of the wound is so much more quickly and easily done, than in the other type of incision. I have no doubt but that every surgeon who familiarizes himself with this incision will get a tremendous amount of comfort and satisfaction in its use.

DR. ROBERT L. SANDERS (closing).—I am pleased that Doctor Singleton has discussed these essays, as he is one of the pioneers who has done excellent work on this problem of transverse incisions in the upper abdomen. I would like to emphasize the fact that there have been two types of incision, one of them dividing the recti muscles and the other retracting them but leaving the fibers intact. Both of these methods are presented in these papers. Doctor Lynn advocates division of the muscles, while I call attention to the method of retraction of the muscles without division of their fibers. By this conservation of the continuity of the muscle fibers, the anatomic and physiologic relations of the abdominal wall are not disturbed and its integrity is maintained. This procedure has been very satisfactory in our hands.

SACROCOCCYGEAL TRANSRECTAL APPROACH FOR REPAIR OF HIGH RECTOVAGINAL AND VESICOVAGINAL FISTULAE

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THE literature concerning the repair of persistent high rectovaginal fistulae deals with various methods of approach, either directly, through the posterior vaginal fornix, or perineally by separation of rectum and vagina up to the region of the fistula. In either case, dissection of the fistulous region with separate closure of the openings in rectum and vagina, attempts at the same time, if feasible, to have the two closures not directly opposite one another. Cutting the anal sphincter or temporarily paralyzing it by stretching, as well as temporary left inguinal colostomy, has been mentioned as useful in putting the operative field at rest until healing has taken place. Suggestions have also been made for various transperitoneal abdominal procedures with the same object in view. A recent experience seemed to suggest a more direct approach to this relatively inaccessible region.

Case Report.—A case of low rectosigmoidal carcinoma was operated upon in the Skin and Cancer Division of the New York Post Graduate Hospital August 21, 1935. The patient was a rather emaciated woman of 54. The tumor was free and its lower margin was just above the bottom of the pouch of Douglas. Through a median hypogastric incision, the tumor-bearing loop was completely mobilized according to the procedure of Miles, without, however, division of the inferior mesenteric vessels. The mobilized loop was then packed down into the pelvis, the pelvic peritoneal diaphragm reestablished, and the abdomen closed. A Mikulicz "vorlagerung" of the mobilized tumor-bearing loop was performed through a sacral approach after removal of the coccyx.* Six days later, August 27, the tumor-bearing loop was amputated flush with the skin. On the tenth postoperative day, August 31, a spur-crushing clamp was applied, which came away at the end of seven days. The spur was, however, not completely divided. With the index fingers in the afferent and efferent loops respectively, it was possible to bring the finger tips together with what seemed to be bowel between. September 19, the clamp was again applied to this spur and at the end of ten days it cut through, but the posterior fornix of the vagina had been caught in with the efferent loop, so that a high rectovaginal fistula, in the median line, fully five centimeters long resulted, with its upper end at the cervical wall. From the vaginal aspect, this rectovaginal fistula was fully three and one-half inches from the perineal margin of the posterior vaginal wall. Through the sacral colostomy opening, however, the distance was not more than three-quarters of an inch from the skin. On October 9, 1935, without enlarging the sacral colostomy opening, it was a simple matter to expose the fistula, dissect the anterior rectal wall from the posterior vaginal wall, and to mobilize both for fully one-half inch from the margins of the opening. The vaginal opening was then closed in two layers, with running sutures of chromicized catgut. The rectal mucosa was readily

* Küttner (Zentralblatt für Chirurgie, p. 604, 1910) reported ten such cases of sacral Mikulicz "vorlagerung" for carcinoma of the rectosigmoid with one death.

approximated. There was no leakage, and, at the end of three weeks, a firm healing had apparently taken place. During this time there was no tension on the plastic repair because the open sacral colostomy, directly opposite, allowed free escape of feces and flatus.

On November 14, under spinal anesthesia, the sacrococcygeal colostomy was closed. A circular incision at mucocutaneous margin freed the intestinal wall liberally, so that the lozenge-shaped longitudinal opening of mobilized posterior rectal wall could be sewed up in a transverse direction. The skin margins were then approximated, except at one point just below end of sacrum where a vaseline gauze drain was inserted. This drain was removed at the end of the third day and the posterior wound gradually healed without leakage. The rectovaginal repair, however, leaked a little for 13 days and then closed spontaneously. Six weeks later the patient reported that there had been no further leakage; regular normal bowel movements, and a gain of ten pounds in weight.*

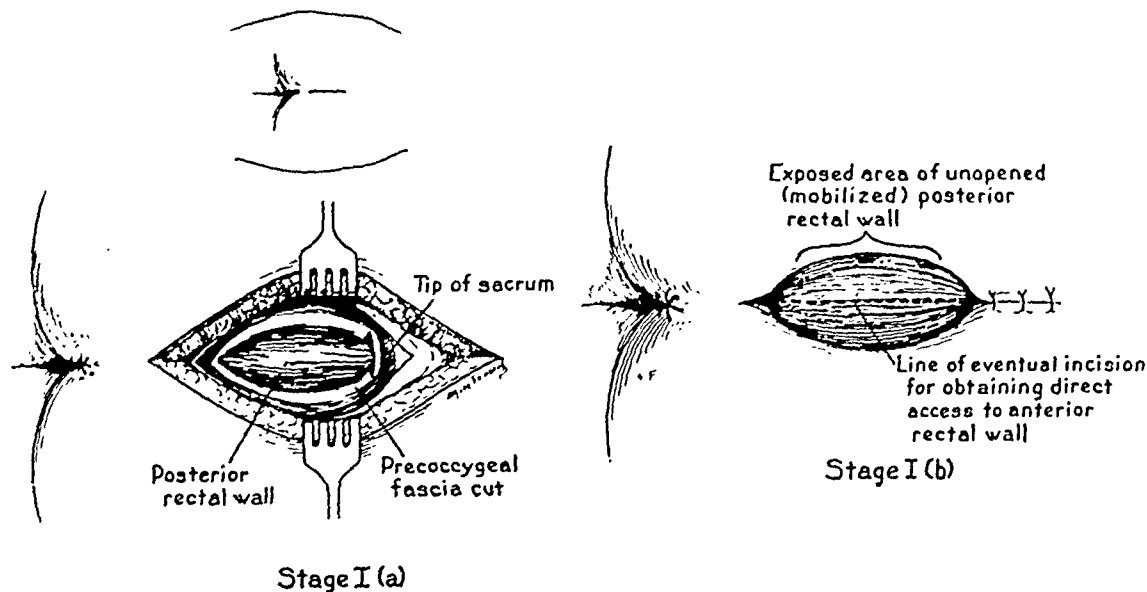


FIG. 1a.—Beginning the exposure of the posterior rectal wall after removal of coccyx and division of precoccygeal fascia.

FIG. 1b.—Rectum has been mobilized sufficiently to permit a longitudinal area of the posterior wall to heal in place, level with the skin surface.

This experience suggested that, in the repair of persistent high rectovaginal or rectovesical fistulae, where much cicatricial deposit might render mobilization and exposure difficult in following previously employed methods, the following sacrococcygeal, transrectal approach might be considered and performed in the appended three stages.

Operative Technic.—I. Exposure of the posterior rectal wall through a median incision, extending from over the lower end of sacrum to within one inch of the posterior anal margin, removal of coccyx (Fig. 1a), mobilization of rectum,† sufficiently to permit delivery of the unopened posterior

* Patient was presented before New York Surgical Society, January 8, 1936. A previous case operated upon according to this method was presented before the Surgical section of the New York Academy of Medicine, January 6, 1928 (Gerster, J. C. A.: Carcinoma of Rectum. American Journal Surgery, vol. 4, No. 4, April, 1928, pp. 444–445), and later before New York Surgical Society, January 14, 1931 (ANNALS OF SURGERY, June, 1931, vol. 93, pp. 1252–1253). She is living and well eight years after operation, January 8, 1936.

† The technic is the same as that described for mobilizing the rectum (for carcinoma), Text-Book of Operative Surgery, by Dr. Theodore Kocher, Third English Edition, translated by Harold J. Stiles. The Macmillan Company, 1911, vol. 11, pp. 651–652, Figs. 385, 386, 387.

rectal wall, so that it lies exposed in the wound at the skin level and in contact with the cut margins of the gaping skin wound (Figs. 1b and 2). A vaseline gauze dressing covers the operated area for a week or ten days to permit healing, thereby avoiding infection of the subcutaneous tissues.

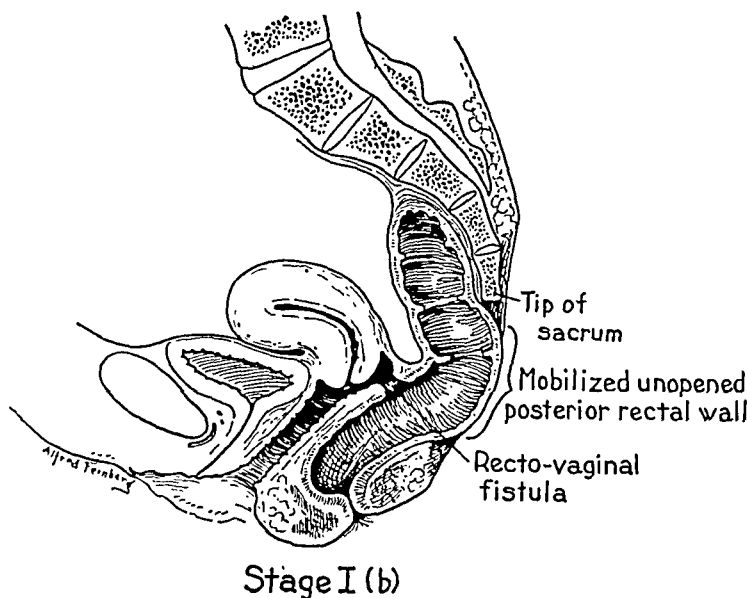


FIG. 2.—Sagittal section of the pelvis. Showing greater accessibility by sacrococcygeal attack than by perineal or vaginal routes.

2. The long oval of exposed bowel wall (Fig. 1b) can now be opened longitudinally with scissors, actual cautery or electric cutting knife. (This obviates the necessity of a preliminary abdominal colostomy.) With proper retraction, the fistulous opening in the anterior rectal wall lies in view directly

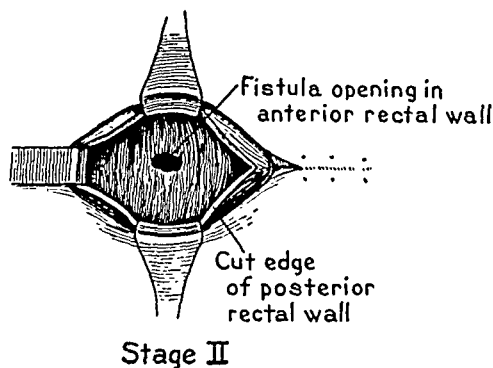
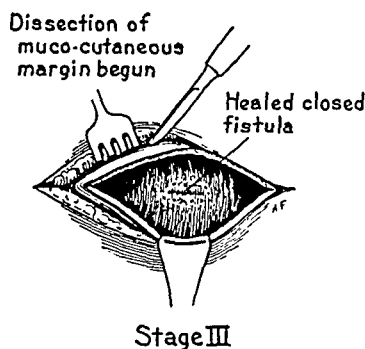


FIG. 3a.—Posterior rectal wall opened exposing fistula on anterior rectal wall. After transrectal plastic closure of fistula, posterior rectal wall remains open until complete healing of fistula is assured.



Plastic closure of posterior rectal wall

FIG. 3b.—Plastic closure of the posterior rectal wall, only after healing of the rectovaginal fistula is assured.

opposite, accessible for repair (Fig. 3a). If the fistula fails to close completely, a second attempt at closure is, of course, feasible. During this period of healing, the presence of the colostomy opening directly opposite, permits free escape of feces and flatus, and thus avoids strain on the suture lines of the plastic repair.

3. Eventually, having satisfied oneself that the fistula is firmly and soundly healed, the sacral colostomy is closed as in final stage of any Mikulicz "vorlagerung" (Fig. 3b).

The advantages of this method are: simplicity, accessibility of the region to be repaired, less risk from infection or of failure than by either the perineal or abdominal route, and lastly, less cosmetic deformity than after other methods of attack.

In traumatic surgery with perforation of the bladder and rectum, it is suggested that, as an emergency measure, an immediate sacrococcygeal decompression of the rectum, as just described, be combined with a suprapubic cystostomy, to prevent infiltration of the pelvic cellular tissue with urine and fèces. The method also may be used to approach certain rectovesical fistulae in the male.

SUMMARY

Recently in the course of cutting through the spur of a double-barreled colostomy after a Mikulicz "vorlagerung" for a low rectosigmoidal carcinoma through a sacrococcygeal opening, a high rectovaginal fistula was incidentally produced.

Repair of this fistula was so easily accomplished through the sacrococcygeal opening, that it is suggested that a deliberate attack by this route for the repair of certain suitable, selected cases of high rectovaginal or rectovesical fistulae is feasible.

URETERAL TRANSPLANTATION AND CYSTECTOMY

ADDISON G. BRENIZER, M.D.

CHARLOTTE, N. C.

COFFEY, in 1909, suggested the submucosal transplantation of the common bile duct or ureter, which procedure was carried out with a ureter by C. H. Mayo in 1912. He then further suggested introducing catheters into the ureters, transplanting them both simultaneously, and finally, the employment of a necrosing suture, transfixing the ureter and intestinal mucosa, after anchoring the severed and tied-off ureter to the intestine in the submucosal position.

Complications, however, arose with the necrosing suture: *i.e.*, (1) Apparently the suture used to tie off the distal end of the ureter should not be used as the necrosing suture, because the implanted ureter might slip its position. The fistula should be established proximal to the end tie, and the tied-off end of the ureter should be anchored to the whole thickness of intestine and not to the mucosa alone. (2) The suture, if tied loosely, failed to cut through, and if tied too tightly, would cut through the intestinal mucosa before cutting through the ureter. (3) The suture failed to enter the lumen of the intestine.

We felt that these difficulties could be overcome by using a metal ring. (1) If the needle bearing the suture were passed through the ring in the intestine, it would of necessity have passed through the intestinal mucosa. (2) There would be no question as to the security of the suture tie, as it could be tied securely and tightly down on the ring. (3) There would be no danger of shifting of the ureter, because the suture and ring held the ureter, with interposed intestinal mucosa in its grip. The suture would cut through the ureter into the intestine, more readily by the pull on the ring from intestinal peristalsis. Added to this, a thread tied to the ring and allowed to escape from the anus could be pulled upon at will and thus aid in the cutting through of the necrosing suture.

Walker-Taylor, in 1932, had already suggested the use of a metal ring. Coffey adopted this procedure, and found it easy to insert the ring on an ordinary curved forceps into the straight rectum of a dog, but difficult to introduce into the human rectum, which is directed backward and to the left, and contains valves and membranous folds. He devised an olive tipped, hollow ended curved forceps, to carry a ligature, through which the necrosing suture was to be passed.

It was found that an ordinary curved forceps, grasping a metal ring, could, without danger, be passed by all folds and valves, when carefully guided from above. If there was any difficulty in passage, the ring could be liberated from the forceps and rolled between the fingers to any position

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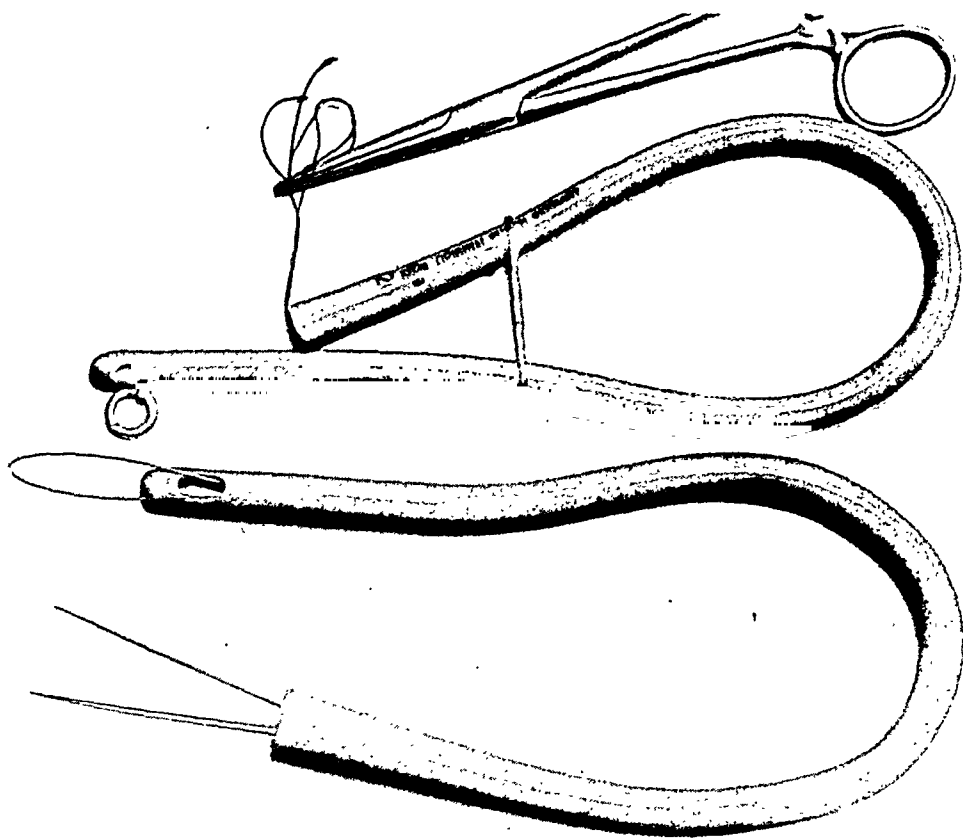


FIG. 1.—Small rectal tubes or catheters of size No. 26F., one threaded with silk holding a small metal ring. The ring is pulled close into the eyelet and passed up by rectum. The other catheter shows the way the long hairpin wire is passed over the ureter in the abdomen and down the catheter. It is better to use a single catheter with side and end eyelets for each ureter, the side eyelet to carry the ring up the rectum and the end eyelet to carry the hairpin wire down the rectum through the catheter.

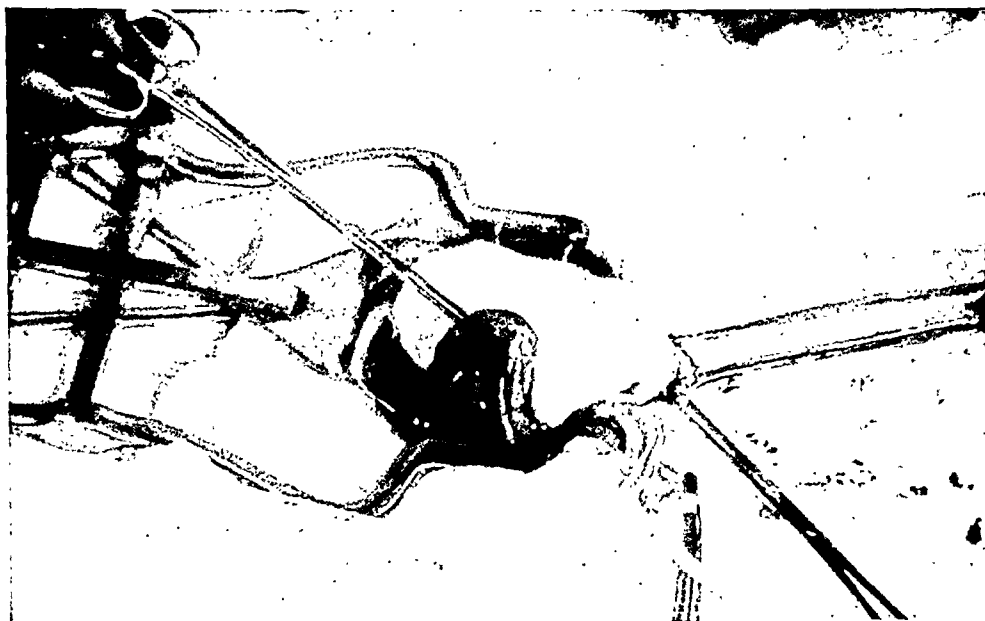


FIG. 2.—The ring is shown in the rectosigmoid passed up in position and the catheter, for illustration, is grasped by an Allis forceps through the bowel wall. These rings may be swallowed, several of them the day before, and pushed up and moved to the proper position.

in the rectosigmoid. Or, for that matter, a ring could be picked up anywhere along the extent of the colon by allowing the patient to swallow several small rings the night before and at operation they could be identified and transferred to any desired position. We have used several sized rings, with or without a tugging thread. A flexible Ochsner stylet and gallbladder probe and a piece of tonsil wire bent like a hairpin were used to pierce the ureter and then be passed down a catheter in the rectum.

Higgins,¹ in 1933, while still employing the submucosal position of Coffey and his necrosing stitch technic, began to experiment on dogs, performing a simultaneous bilateral transplantation of the ureters. Walters, in 1933, stated that: "Higgins has modified this method (the transfixion and necrosing suture method) by not dividing or occluding the ends of the ureters until the ureterosigmoidal anastomosis has established itself; he prefers division or occlusion later, when the bladder is removed. In an experimental study of the so-called aseptic, suture-necrosis method, Mann and I found that immediate or eventual hydronephrosis occurred so frequently, even though urine appeared in the rectum from the fourth to the sixth day in most cases, that I have been fearful to use the method clinically." Higgins, in 1934, stated: "I have collected a series of 52 cases with three fatalities. We are more than enthusiastic over the results we have secured with its use during the past year."

My opinion, from what I can gather from various sources and from my own experience, is that there is no objection to the necrosing suture method, when properly applied, to create an appreciable fistula between the ureter and intestine, and that the lateral anastomosis without interruption of the continuity of the ureters, of Higgins, is the one revolutionary suggestion and most ingenious method since the original "submucosal transplantation" of Coffey.

ILLUSTRATIVE CASE REPORT

In Which Higgins' Technic Plus the Ring Was Employed

W. M. H., a Negro girl, aged 15, had had a difficult forceps delivery the previous year. The anterior wall of the vagina and bladder were badly lacerated, leaving a large, scarred, irreparable vesicovaginal fistula.

Operation.—General anesthesia (gas-ether). Midline incision below the navel, Trendelenburg position, whole pelvic basin exposed. Both ureters easily identified without catheters, peritoneum incised and ureters gently stripped from their bed for an extent of three inches, as low as possible along the pelvic wall where they could be most conveniently laid against the rectosigmoid. Incisions were made into the rectosigmoid, lower on the left side than on the right, through the serosa and muscularis down to, but not into, the mucosa. The ureters were placed in their submucosal beds, for a distance of about one and one-half inches and anchored in place at their lower ends by taking a stitch twice through the ureters and once through the intestinal mucosa and ring, which was held like a darning egg in the rectum against the mucosa. The ring, tied with a silk thread, and held by a long curved forceps, had been placed in the rectum before the operation began. There had been no cleansing of the rectosigmoid other than by an enema. The competency of a lacerated perineum had been

URETERAL TRANSPLANTATION

proven by the injection of water and air. The rings were pushed up from below, while being guided from above, until they reached the desired position, when they were grasped with Allis forceps applied through the whole intestinal wall, thus estab-

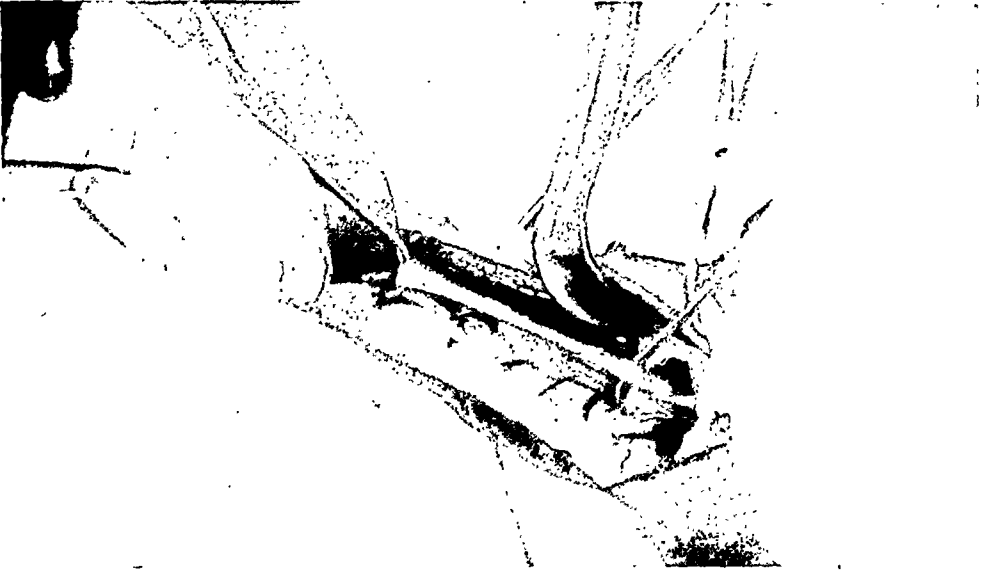


FIG. 3.—Exposure of the rectosigmoid, bladder and ureter; the ureter is held on two blunt hooks.

lishing a fixed point, holding the intestine perfectly and serving to facilitate the incision down to the mucosa and the laying of the transfixion and necrosing stitch through the ureters and through the rings. These silk necrosing sutures were tied securely on the

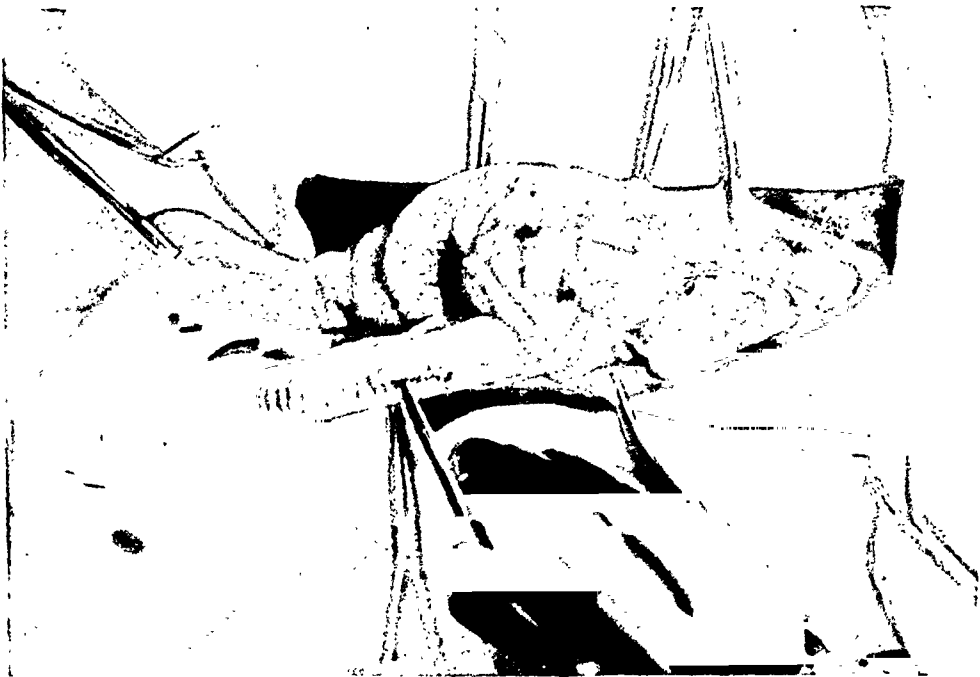


FIG. 4.—The catheter and ring shown in Figs. 1 and 2 are shown; the catheter grasped and used as a darning egg is cut down upon incising muscularis down to the mucosa. The ring in the bowel against the mucosa is being pointed out with the knife at the top angle of the incision.

rings. The muscularis first, and then the serosa were sutured over the ureters with a Lembert stitch of No. 0 chromic catgut. The lateral flaps of the parietal peritoneum were then sutured, over this line of suture, to the rectum.

The bladder was pushed away from the peritoneum above and around to the sides.

forcing it as far as possible under the symphysis, and in closing the peritoneal wound the peritoneum was anchored high to the muscle and fascia, thus beginning the liberation of the bladder and creating a much larger preperitoneal space for the anticipated cystectomy. Two Penrose drains were placed in the bladder space for 48 hours.



FIG. 5.—The catheter in the rectosigmoid with the ring is now pulled down two-thirds the length of the incision; then a silk suture is first made to pierce the ureter and then through the ring in the bowel and the ureter is tied down on the ring. The figure illustrates the site of the ring and the suture through it. This is the necrosing suture.

There was but little postoperative reaction. The urine began to flow per rectum within 48 hours. The rings bearing the necrosing ligatures came away on the sixth and tenth days respectively. The fistulae were established by gentle traction on the

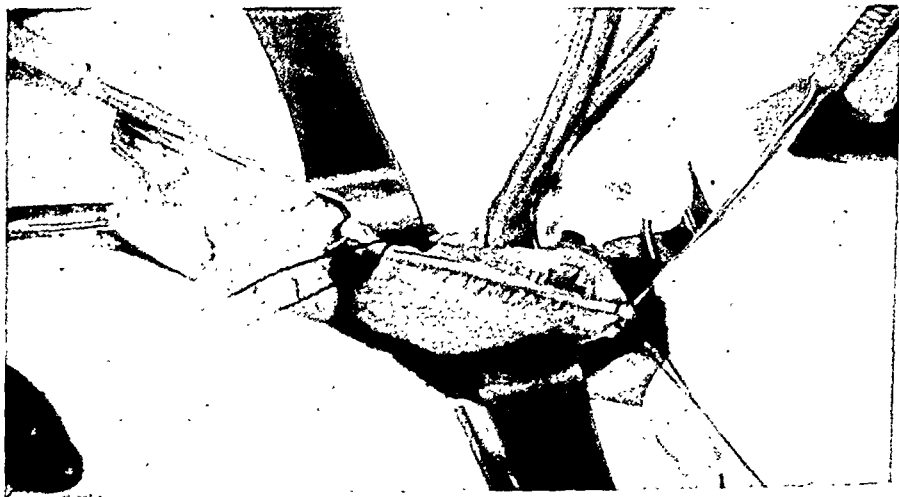


FIG. 6.—Incision down to the mucosa, stretch of ureter about two inches long lying on mucosa and held in position by two interrupted Lembert sutures, one at each end.

rings some time before complete necrosis had occurred, which allowed their ultimate liberation.

The cystectomy was completed a month later. On account of the separation of the peritoneum and its anchorage in a higher position, and the separation of the bladder

at the first operation, there was very little hemorrhage. The ureters were identified as they entered the bladder and as they tugged upon the rectum when pulled upon. A small slit was made into the peritoneum, the distal portion of the ureters clamped at the point of emergence, tied with chromic catgut, and tucked into the rectum. The small peritoneal opening was sutured. The dissection of the bladder was carried down to the scarred opening high in the anterior vaginal wall, which was left open for subsequent drainage. The mucosa of the trigon and the posterior urethra was hollowed out by dissection and cautery. Two Penrose drains were inserted, one above and one below. The postoperative course was uneventful.

After the wide separation of the bladder at the first operation, the removal of the bladder from below was considered, but abandoned because: (a) The approach would have been through a urine drenched field; (b) the high position within the abdomen, where the ureters emerged from the rectum, would have been difficult to reach; and (c) the opening of the

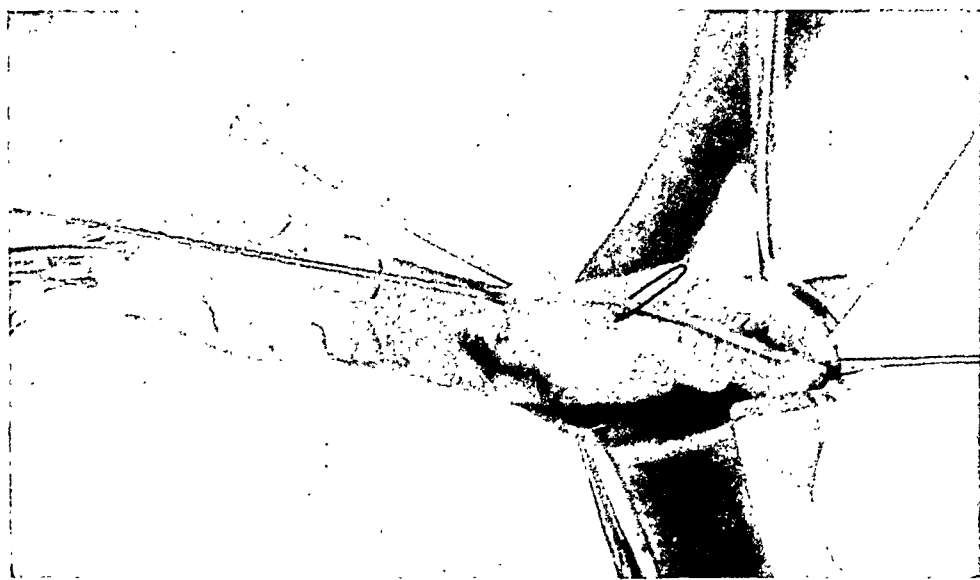


FIG. 7.—Hairpin wire looped over the ureter, about one-half inch above the lower angle, and passed through the mucosa down the end eyelet of the catheter and out of the anus. It is this wire, which will cut through the ureter on the tenth day either by pressure necrosis from traction or by burning under the application of an electrocoagulation current. This severing of the ureter is done after the fistula between the ureter and bowel is secured by the cutting through of the necrosing suture on the fourth to sixth day. Traction on the hairpin wire may be secured by attaching the ends of the hairpin wire to a rubber band stretched between the legs. The final technic of the operation will dispense with the necrosing suture and produce the fistula and at the same time sever the ureter with a single hairpin wire over each ureter.

peritoneum by this route might have caused infection. In addition, by severing the ureter at the bladder, without reoperation and without reopening the peritoneum, a fistula may remain, which can be removed from below. The bladder can be more readily separated when outlined under gentle distention, which is not applicable if fistulae are present. Care is required to remove the bladder intact with ureters attached. Nevertheless, with the separation at the first operation, which can be nearly complete, so long as the ureters remain attached intact, and will flow, the bladder in the female can be removed from below, along with the urethra through the vagina.

Feeling that if a loop of tonsil wire No. 9 or less, could be looped over the ureters they could be severed in position, without removing the bladder,

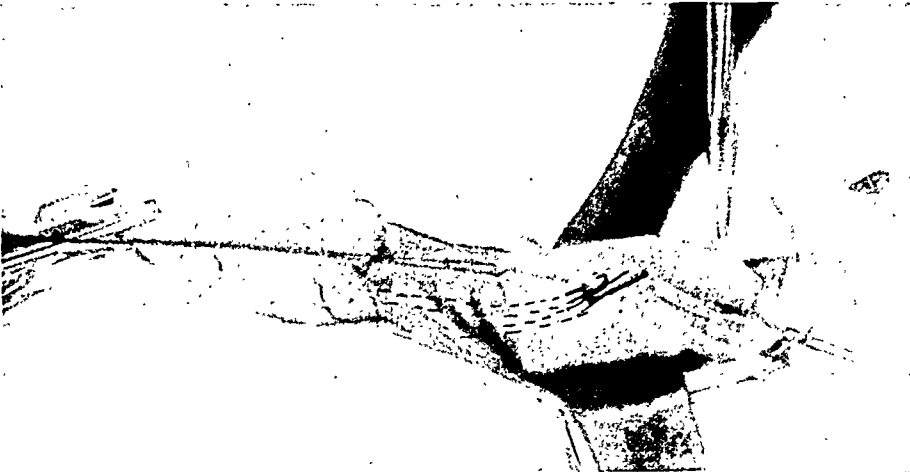


FIG. 8.—One wire loop holding down the lower end of the ureter, the loop to sever the ureter. A second wire loop, above this one, transfixing the ureter, to cut through by necrosis or burning and create the fistula or uretero-enterostomy.



FIG. 9.—The muscularis and serosa of the rectosigmoid is closed over the stretch of the ureter, lying on the mucosa. The hairpin wire, looping over the lower end of the ureter and passing through the mucosa and out the anus, is pushed back up through the stitch line to illustrate its position, well above the emergence of the lower end. It is this wire which severs the ureter.



FIG. 10.—The ureter lying on the rectal mucosa, the hairpin wire loop, pulling down on the lower end and emerging through a rectal tube by rectum. The electrocoagulation electrode being applied, first to transfixion wire, creating this fistula and then to the looping wire severing the ureter.

or, if the bladder were removed, the operation would be simplified by having the ureters already occluded and embedded, the following technic was evolved: A rectal tube was inserted into the rectum. Both ureters were rapidly exposed. Two incisions were made into the rectosigmoid through serosa and muscularis down to the mucosa. A piece of tonsil wire was bent like a long hairpin and looped over the lower end of the right ureter and passed through the mucosa, at the lower end of the incision, into the open end of the rectal tube. The rectal tube was shifted down and the same procedure performed with the left ureter. The muscularis and serosa were closed over the ureter. The lower ends of the transfixion wire were bent for identification and attached to slight elastic tension. After three

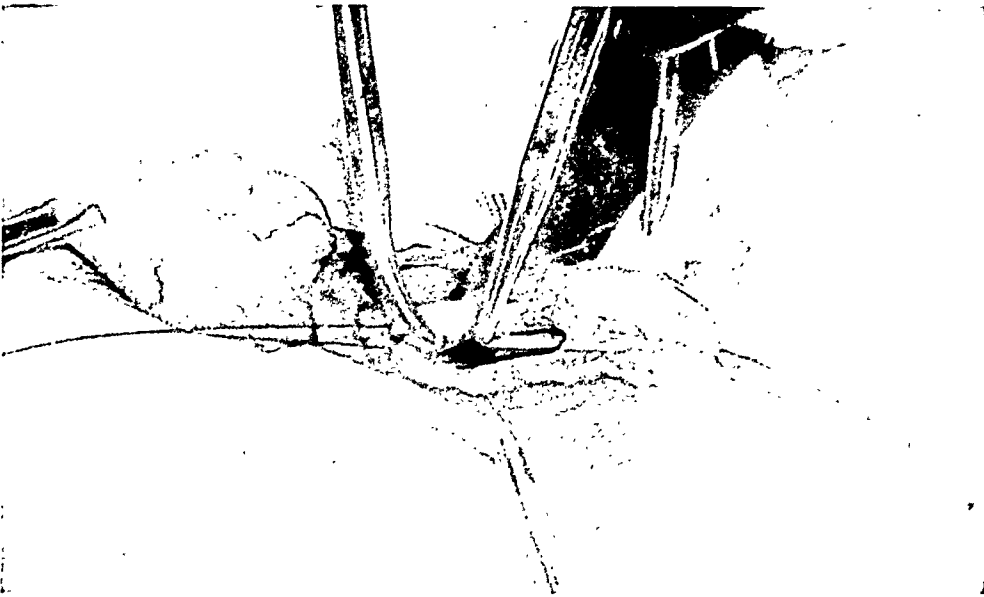


FIG. 11.—The two ends of the ureter after cutting with the hairpin wire loop on applying the electrode of the cutting current below. The loop is again pushed up over the ureter (shown just above the upper clamp). If the ureter is pulled down upon hard by the loop and the current is very weak, there is practically no damage to the surrounding intestine and the ends pull apart for some distance. The fate of the upper burned end depends upon the function of the fistula (uretero-enterostomy) above it. Either closed or open would be satisfactory.

days, under the guide of a proctoscope, a small rectal tube was passed over the transfixion wire to insulate it and the wire was touched with an electro-coagulation electrode, which resulted in the wire cutting through. On the twelfth day the lower wire, looping the ureter, was pulled down upon hard, and a low current applied to the electrode so that the effect would be not only to cut slowly through the ureter and rectal mucosa and not to necrose the tissue except for a slight distance around, but also, through the pull, to dislodge the ureteral ends. Here the great advantage lay in not having to reoperate to disconnect the ureters from the bladder and another definite feature was not having to reenter the peritoneum, even when carrying out the cystectomy.

The fate of the looped and severed lower end of the ureter should depend, in large part, on the function of the fistula above it. If functioning actively, the lower end would probably close. It might, however, discharge urine, but as

the place where it is severed lies behind serosal flaps, it would be likely to close with the aid of intra-intestinal pressure, as in an enterostomy. If this should fail, there is still another opportunity to close it when the bladder is removed. Thirteen ureters thus far have been transplanted in man, and innumerable ones in dogs.

RÉSUMÉ OF TECHNIC.—None of these cases has had any particular

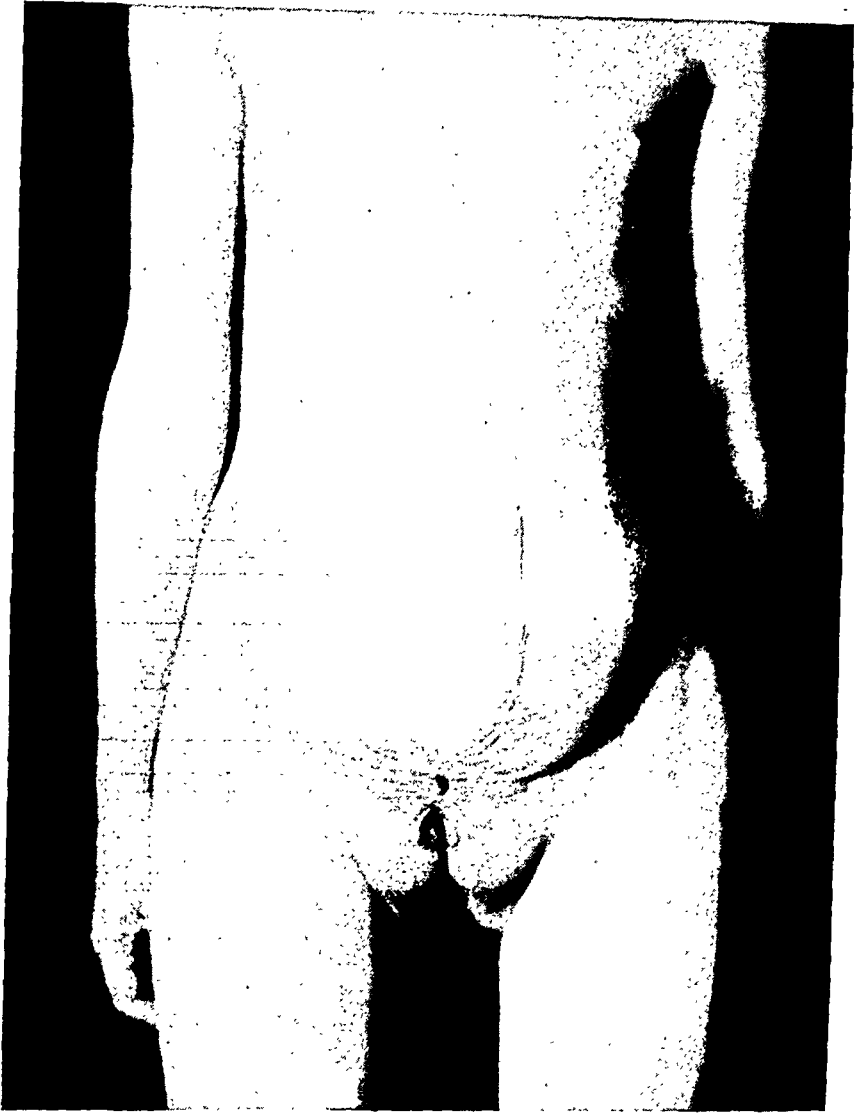


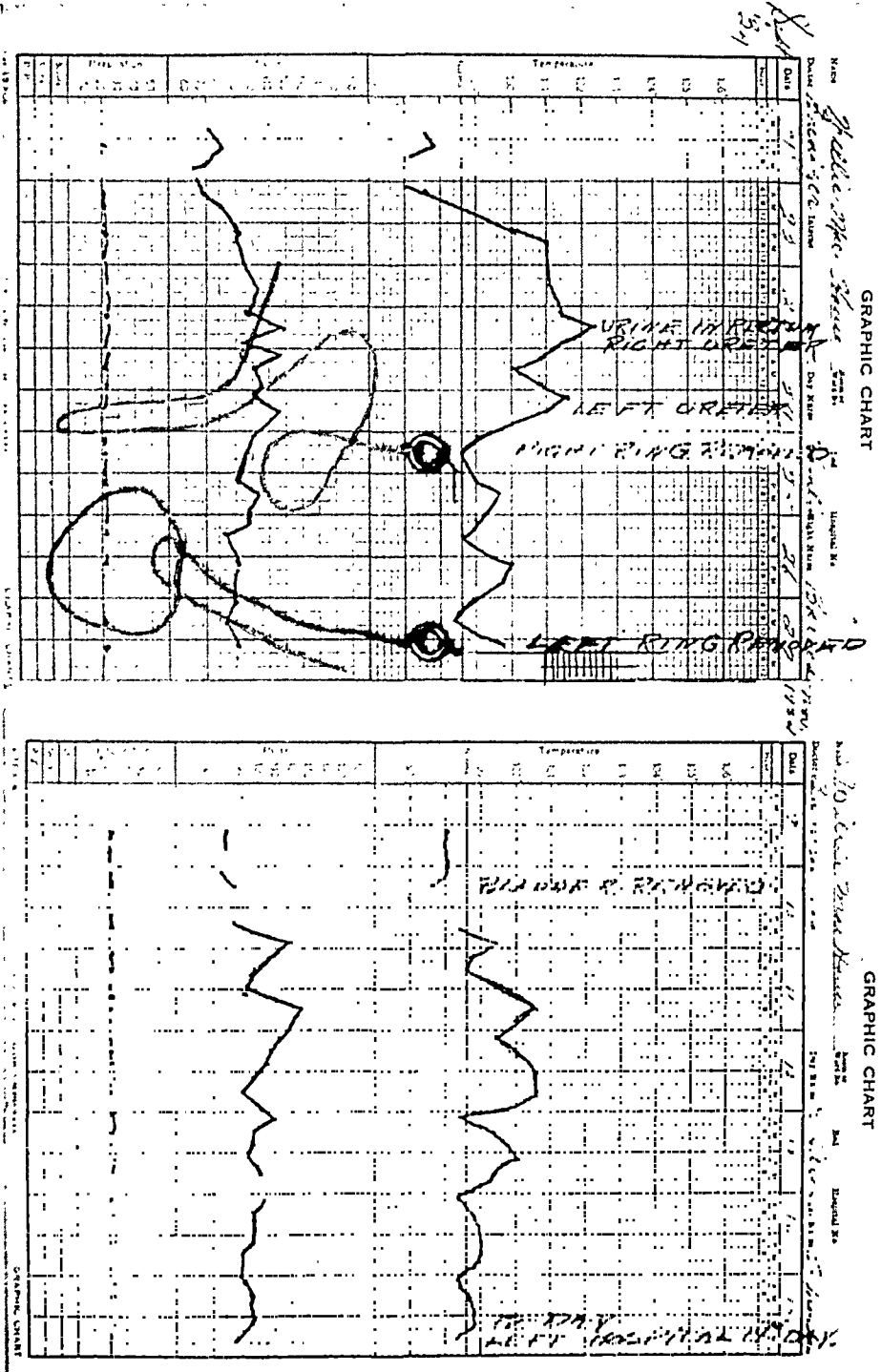
FIG. 12.—Case of exstrophy of the bladder, after transplantation of one ureter at a time according to Coffey technic No. 3 and the Brenizer ring technic and removal of the bladder. Now awaiting a better plastic procedure of the bladder and vulval regions.

preparation of the rectum and colon beyond emptying them. An empty and dry sigmoid and rectum is preferable. When the patient is on the operating table two catheters, number 24 or 26, armed with a small ring at the upper opening (better with opening on the side) and the thread attached to the ring passing through lower opening, are placed in the rectum.

Operation.—In cases of epispadias, with absence of urinary sphincters, lower fistulae and carcinoma of the bladder, the incision is made in the mid-

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Fig. 13.—Case of large vesicovaginal fistula, fistula admitting four fingers, where both ureters were transplanted at the same time by the Coffey-Higgins-Brenizer technic. The temperature, pulse and respirations chart and the time of detachment of the necrotizing sinuses on the Brenizer ring.



line. The bladder is separated from the peritoneum and around the front and sides, facilitating the future removal at a later stage. If this is done in the female, the bladder can be removed later from below through the vagina. Both ureters are exposed for an extent of two or more inches, as low as possible, in the pelvis and manipulated gently on two blunt hooks.

First, one of the catheters, bearing the ring and thread, is passed up to a high position, higher than the position where it is to be ultimately applied.



FIG. 14.—Bladder removed from same case as Fig. 13. Note the whole floor of the bladder, a tremendous fistula. Note the bladder ends of the ureters, with probes in them. In this case the ureters were carefully traced back to their emergence from the intestine, on the way to the bladder, severed and the stumps tucked back into the intestine. This step is not necessary when the ureter has been severed by the loop of the hairpin wire already described and, directly, to be portrayed in the following cases.

The catheter is then caught between the fingers and used like a darning egg to cut down upon. The edges of this incision through serosa and muscularis are separated, exposing the mucosa for half an inch in width and two and a half inches in length, which offers an adequate bed and covering for the ureter. The ureter is placed in the bed and may be held there by a suture at upper and lower ends.

The catheter with ring and thread is now pulled down until the ring is in the proper position, *i.e.*, at the junction of the upper two-thirds with the

lower one-third of the incision. At this location the ureter is pierced once or twice with a silk suture and the suture passed through the ring and tied securely.

The catheter is then moved to a slightly lower position, but still well above the lower angle of the incision, and a long hairpin wire is passed over the ureter down the catheter. The muscularis and serosa are closed over the ureter. The same is done with the left ureter at a lower level.

The catheters may be withdrawn or left in place. Preferably, left in place in the rectum, if they stay, or are not uncomfortable. The catheters,

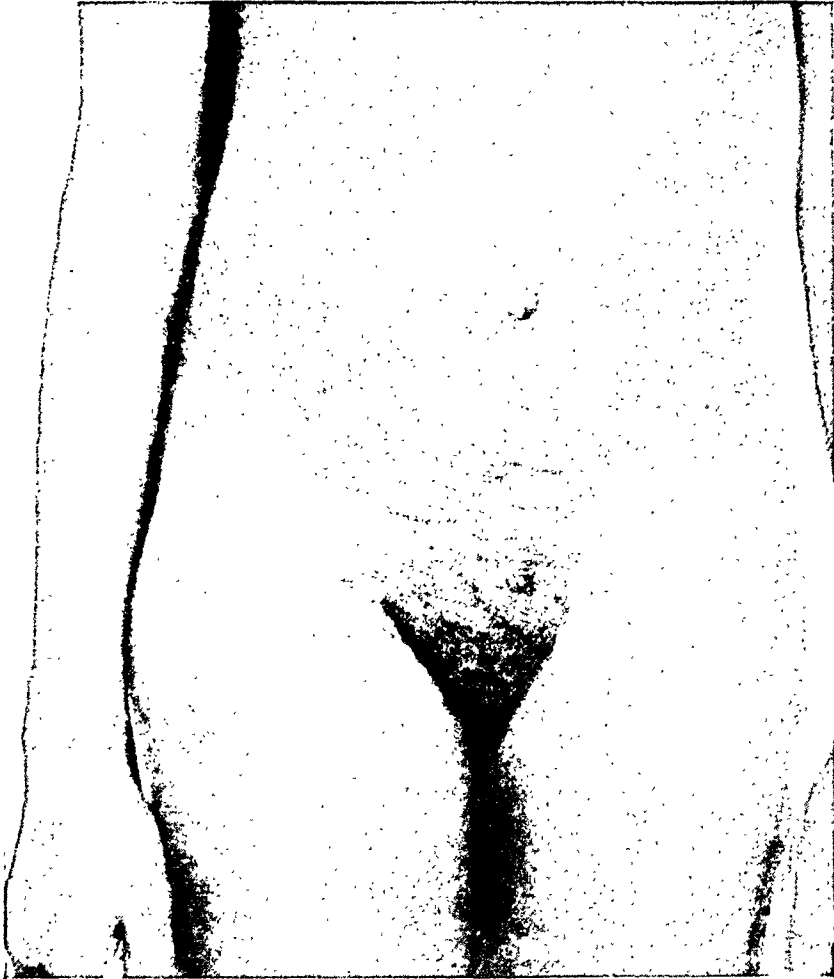


FIG. 15.—Same case as Figs. 13 and 14 after transplantation of both ureters and removal of the bladder. The patient empties her bowel four times a day and occasionally once a night.

ring and thread, and wire can be adjusted from time to time and the ring and thread gently tugged on.

On the fourth to sixth day the ring bearing the necrosing suture comes away and on the tenth to twelfth day the hairpin wire is pulled down upon and the electrocutting current applied to ends of wires. I have demonstrated in the dog that the cutting of the ureters is easily accomplished and effective, that there is very little charring when a low current is used, that there is more or less spreading of the cut ends, and that there is complete, or almost

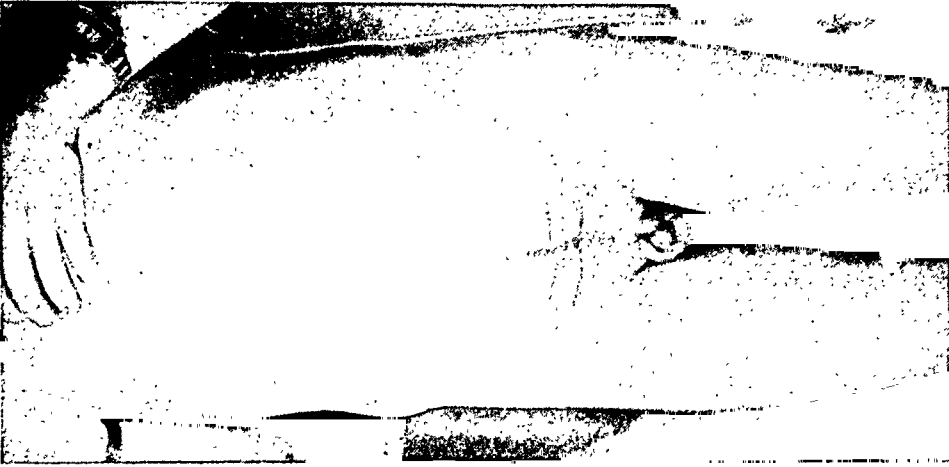


FIG. 18.—Same case, after removal of bladder and awaiting final plastic on urethra.

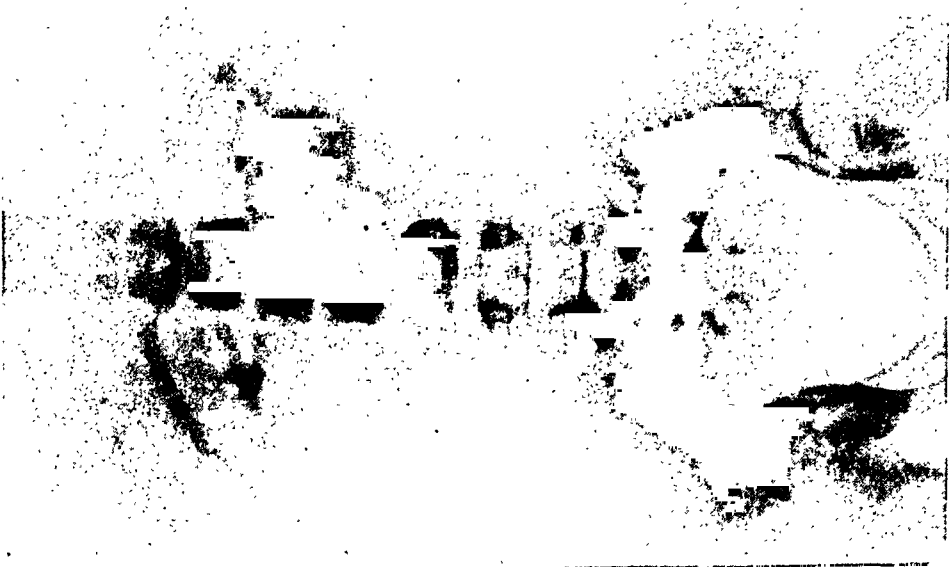


FIG. 17.—Same case showing the flow of urine after intravenous skiodan.



FIG. 16.—Case of epispadias, with incompetent vesical sphincters already having been operated on, when a cystostomy and attempt at repair of urethra was performed, now after transplantation of both ureters at a time by the Brenizer technic.

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complete cessation of escape of urine from the lower portion of the ureters into the bladder.

All of the above steps are preparatory to the secondary operation of cystectomy, which is a comparatively easy procedure with the ureters already severed and both ureterocolonic fistulae having been established by means of the ring and necrosing suture.

The bladder may be removed without particular regard for the portion of the ureter remaining from the point where it has been severed to the bladder. This may be tied off at the bladder, traced back to the intestine and tied off there, or simply avulsed. When the end is closed after merely

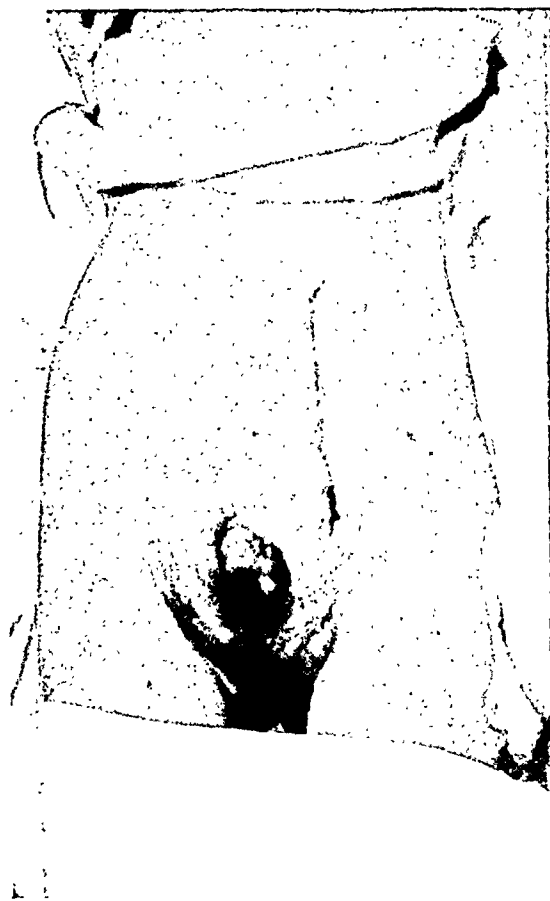


FIG. 19.—Case of exstrophy of the bladder in a girl aged 18, after the transplantation of both ureters at the same time, according to the Brenizer technic.



FIG. 20.—Same case showing the flow of urine after intravenous skiodan. Note the nephroptosis on the right side and the hydronephrosis on both sides, somewhat improved, but almost identical with urogram before transplantation. These cases should be operated upon early in life to prevent too large an hydronephrosis. They will probably develop some hydronephrosis, even when operated on.

creating a fistula, the proximal end of the ureter must be embedded in the intestine. The real advantage of this method lies in not having to reopen the peritoneum to embed the distal end of the ureter but merely to tie it off, disregard it or avulse it. In certain cases of fistulae and inoperable carcinoma, the bladder is not removed. When the bladder is removed it is quite a simple procedure to close the dead space in fistulae and carcinoma cases but not in cases of exstrophy where the symphysis is widely separated. In

such instances the structures must be widely dissected out, including a separation of part of the insertion on the symphysis of the recti-abdominis muscles and a liberation from their posterior sheaths to make a satisfactory union. It is never advisable to do a bone plastic with the idea of uniting the separated symphysis, on account of the encroachment upon the pelvic brim. A possible consideration is the placing of a bridging bone graft between the separated portions of the symphysis.

SUMMARY

A technic has been described where a ring on a thread in a catheter was

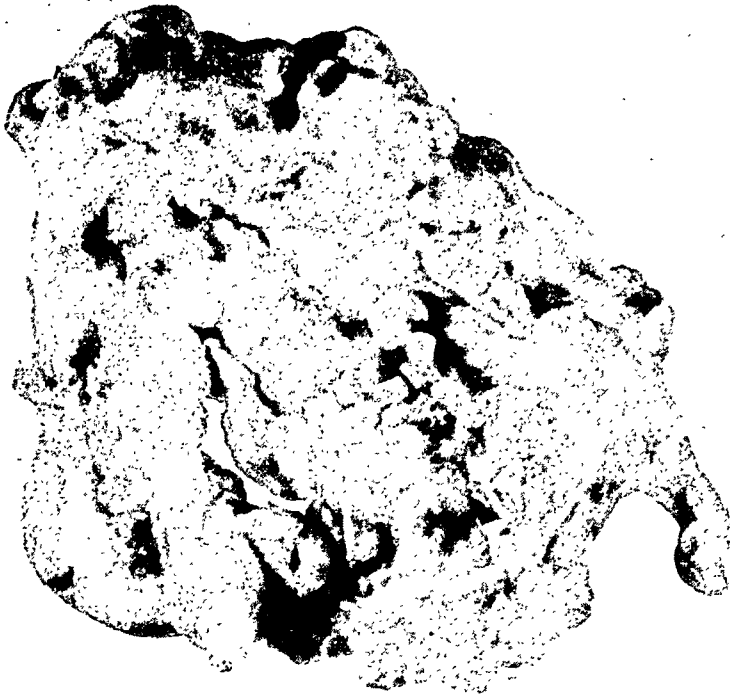


FIG. 21.—Bladder removed from same case as Figs. 19 and 20. The bladder may be rather carelessly dissected out, with a knife, electrocoagulation knife preferably, or even with a thermocautery. When the ureters are reached they are merely tied and cut or only cut and not tucked back into the intestine. As is well understood, the ureters have already been severed with the loop over the ureter of the hairpin wire.

conveyed by rectum to a selected site in the rectosigmoid for implantation of the ureter; the ring is caught with a silk suture which has previously been passed through the ureter. A hairpin wire is then passed down the catheter, looping over the lower end of the ureter, piercing the mucosa and on out the anus.

While it is safer and more secure to first create the fistula with the ring and necrosing suture and then sever the ureter with the wire, the wire alone, certainly in the dog, can be used to sever the ureter (electrocutting) or to

gradually necrose through the ureter under traction or to temporarily occlude the ureter for experimental purposes.

At the present time both ring and necrosing suture and wire will be used, but later the single hairpin wire over each ureter may be employed, at the same time, to sever the ureter and thus create the fistula. In this event the operation would again be materially simplified.

FIG. 22.



FIG. 23.



FIG. 22.—Dissection in the same case, showing the removal of the bladder (Fig. 21). The ureters have been severed close to the bladder and the portions running from the rectosigmoid to the bladder have been grasped by forceps. The retractor in the midline indicates the upper angle of the wound. The recti muscles have been widely dissected out and partly cut away from the symphysis. Note that, when other operations are performed, the ureters must be followed into the intestine, the peritoneum opened and the stumps tucked in, to surely prevent a leak and fistula. With the Brenizer technic the ureters have already been severed by the hairpin wire and the burned or necrosed ends are concealed in the intestinal wall. The ureters may be clamped, tied and cut or simply cut and disregarded. Herein lies the great advantage of the Brenizer technic in cystectomy, the ureters may be entirely neglected, the bladder rapidly removed and in fistulous, and certain cancer cases, not removed at all, since there is no visible urine flow.

FIG. 23.—Same case after transplantation of both ureters at a time and then rapid removal of the bladder and immediate closure. It is also evident that after the ureters have been severed by the hairpin wire, there is no more flow of urine to the bladder region, therefore, the region can be thoroughly prepared and cleansed, the bladder rapidly removed and the wound closed.

DISCUSSION.—DR. HENRY L. DOUGLASS (Nashville, Tenn.).—During the last three years, Dr. L. W. Edwards and myself, working in the Surgical Laboratories of Vanderbilt University School of Medicine, have undertaken animal experiments in the field of uretero-intestinal anastomosis. Among our dogs, infection caused such a high postoperative mortality that we became interested in developing an aseptic technic for anastomosing the ureters and the sigmoid, a technic which appears to be similar in certain respects to the method which Doctor Brenizer has just presented.

The first stage of the Ferguson aseptic two stage operative method of ureterocolic transplantation is technically easy to perform. However, this procedure is immediately followed by partial blocking of both ureters, as indi-

cated by an elevation in the non-protein nitrogen of the blood and a decrease in the amount of urine entering and leaving the bladder. We performed the first stage of this operation on 21 dogs. One dog died of rabies on the eighth postoperative day, which was the only fatality. Daily determinations of the N.P.N. content of the blood showed a rapid rise to a peak averaging 100 mg. on the fifth postoperative day, then a gradual decline until a normal level was reached on the fifteenth postoperative day. Subsequently these dogs remained normal in every particular, and we concluded that a few days of partial ureteral obstruction caused as a rule no permanent damage to the parenchyma of the kidney.

The second stage of Ferguson's operation on dogs proved unsuccessful. Attempts to complete the anastomosis by his method were almost universally followed by the death of the animal within four weeks.

At postmortem we always found evidences of ureteral obstruction in the fistula, which had been created between the ureter and the bowel, and secondary infection in hydronephrotic kidneys. Many modifications of this technic were tried, but we were unable to produce, by this method, a fistula which would remain adequate. Furthermore, the later results which followed the use of Coffey's transfixion suture were disappointing.

Our experiments with each of these methods led us to believe that anastomosis by means of a side to side fistula tends to develop subsequent stenosis and obstruction. It seemed to us more desirable, therefore, to have this end of the ureter open directly into the lumen of the bowel. To accomplish this and at the same time preserve the undisputed advantages of Ferguson's first stage operation, we modified that procedure by looping a No. 27 gauge silver wire over the ureter, the limbs of the loop passing through the intestinal mucosa about one-half inch above the lower angle of the incision in the muscularis. The wire is about three feet in length, so that the limbs can be brought well outside the anus. The ends of the wire loop are fastened together with a shot just within the sphincter and the excess wire cut off. We found that one loop over each ureter is sufficient. The muscle layer of the bowel is then closed over each ureter and its encircling loop, and ten days or two weeks allowed to pass before completing the anastomosis.

I called attention to the fact that Ferguson's first stage operation produced, during the first 15 days, a partial ureteral obstruction which later disappeared without causing permanent damage to the kidneys. However, when the first stage is modified by a silver wire looped over the ureter, as previously described, both the degree and the duration of obstruction is increased. During the 10 to 14 day interval which one must allow for healing, before the loop can be removed through the rectum by means of the electric current, marked changes take place in the renal parenchyma, which are permanent and frequently fatal. During this period the N.P.N. of the blood is often observed to reach 200 mg., and, in one instance, 340 mg.

I wish to emphasize, therefore, the importance of draining the renal pelvis with ureteral catheters during the period in which the loops are *in situ*. Just before the operation is begun, the patient should be cystoscoped and a No. 7 ureteral catheter passed to either kidney and left in place. Their presence will in no wise interfere with the operation, and they should not be removed until just before the wire loops are cut out.

During the operation for cancer of the bladder, while the posterior layer of the peritoneum is open on either side, the internal iliac arteries should be ligated. This causes no damage to the pelvic organs, and has the following advantages: It stops the intravesical hemorrhage of cancer; the growth of malignant cells may be temporarily impaired, and direct extension and me-

tastases delayed. Moreover, if the cystectomy is done within 15 days, or before collateral circulation is established, it is almost bloodless and can, therefore, be done in a much shorter time and with less risk to the patient.

DR. ELLIS FISCHEL (St. Louis, Mo.).—I have grown hot and cold over this subject of ureteral transplantation ever since 1922 when I performed my first and only successful case of total cystectomy for cancer of the bladder. This patient, now 72 years of age, has had both ureters emptying into the rectum for 13 years. Except for nocturnal incontinence, he is comfortable and enjoys average health for a man of his years. I have operated upon eight patients for a similar condition, and the longest postoperative survival has been eight weeks.

At the Barnard Free Skin and Cancer Hospital we hold that only one type of carcinoma of the bladder justifies ureteral transplantation. This is the type in which the base and at least one ureteral orifice is involved in the growth, and in which radiation from radon in gold "seeds" has failed. Therefore, these cases always have dilatation and infection of at least one ureter and are poor surgical risks—so that the problem of ureteral transplantation is much different from that encountered in exstrophy of the bladder or in experimental work on dogs. One, two and three stage operations have been attempted. Coffey's first, second and third methods have been scrupulously followed. I have tried to minimize the infection from the involved ureter by preliminary nephrostomy. The patient went home to recuperate from this operation and died before any direct attack on the ureter could be made. One patient had double ureters from each kidney, necessitating four implantations instead of two. This patient survived long enough for healing to take place and the postmortem specimen afforded interesting material for study. With increasing experience, I feel that the one stage operation is as safe as any, because after removal of the bladder the depths of the pelvis can be better drained. My patients have died from infection, which I feel is always possible either from an infected ureter or from the interior of the bowel, even though the bowel has been entered merely by one stitch. Doctor Brenizer's method for uretero-intestinal anastomosis may have advantages. I hope he will have ample opportunity to demonstrate its repeated success, especially for the sake of that most miserable patient who is afflicted with carcinoma of the base and trigone of the urinary bladder.

DR. L. W. EDWARDS (Nashville, Tenn.).—I agree with Doctor Fischel that infection is the main obstacle to successful uretero-intestinal anastomosis. In collaboration with Doctor Douglass we have been working on a method to obtain an aseptic technic for ureterosigmoid anastomosis but have not at this time operated upon a large enough number of cases to justify a clinical report. One case has been operated on in which we used the Ferguson technic of placing the ureters in the bowel wall to obtain a valve effect, but allowing the ureters to continue their course uninterrupted into the bladder. On the tenth day the ureters were cut through by the silver wire, with the cutting current, as described by him. The blood chemistry was done every day for a period of two weeks following the second stage and the kidney function remained apparently normal. Ureteral catheters were left *in situ* during the period of ten days between the first and second stages. At the end of one week following the second operation the patient was in good condition, with normal temperature and normal kidney function, at which time a total cystectomy was done for an extensive carcinoma of the bladder.

During the first operation when the ureters were embedded in the bowel wall both internal iliac arteries were ligated; this facilitated the operative pro-

cedure of total cystectomy by reducing hemorrhage to a minimum. Convalescence was smooth and uninterrupted, and at the present time the patient is perfectly comfortable with satisfactory ureteral drainage.

DR. ADDISON BRENIZER (closing).—If I have failed to demonstrate how very simple this operative technic is it has been on account of my failure to properly express myself, for I hoped to give the impression that it was particularly uncomplicated. It frequently takes two hours for other methods while with the suggested technic both ureters can be transplanted in three-quarters of an hour. It resolves itself into simply placing both ureters in the rectum upon its mucosa. Then take the hairpin wire, slip it over, close the muscularis over it, suture, and the operation is completed. Then with an open ureter with the wire over it, the current is turned on and it is cut.

REFERENCE

- ¹ Higgins: Aseptic Uretero-Intestinal Anastomosis, in Surg., Gynec., and Obst., September, 1933; Am. Jour. Surg., November, 1933; and Jour. Urol., June, 1934.

STRICTURES OF THE PROSTATICO-MEMBRANOUS URETHRA*

NEWER METHODS IN THE MANAGEMENT OF DIFFICULT LESIONS

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THE technical care of strictured conditions in the deep urethra, resulting from traumatism, disease or operation, often presents a serious problem. I wish to bring before you some of the methods that we have employed to combat the difficulties encountered.

CASE REPORTS

Case 1.—*Ruptured Urethra.*—J. M., male, aged 44, admitted September 3, 1931, for relief of impermeable stricture of the posterior urethra. Seven years previously a large generator had fallen upon the patient, from which he sustained a traumatic rupture of the urethra. An immediate operation, supplying suprapubic drainage of the bladder, and perineal drainage of the prostatic region, was performed elsewhere. Many subsequent operations were performed, in attempts to cure the impermeable stricture of the urethra which resulted.

When admitted to Johns Hopkins Hospital the patient had a permanent suprapubic drain. It was impossible to pass any instrument, and a long area of scar tissue, with complete obliteration of the urethra, was discovered at operation, after the excision of which it was possible to carry out an end-to-end anastomosis of the prostate to the membranous urethra. The immediate result was excellent, but after the patient returned home, he failed to secure periodic dilatation of the urethra.

After many months he returned with a very tight stricture of the urethra, through which urine was voided with great difficulty. Examination showed the apex of the prostate and membranous urethra surrounded by much fibrous tissue. In front of this the bulbous urethra was considerably dilated and pocketed, as a result of numerous attempts to pass instruments into the bladder. Catheters and sounds met with a very firm obstruction. Filiforms engaged in something, and may have entered a short distance into the membranous urethra (Fig. 1, No. 1), but buckled two or three times upon themselves.

Reviewing the case, it was evident that two conditions had to be dealt with: (1) The difficulty of engaging and penetrating the urethral lumen of the strictured area, owing to the irregularly dilated urethra immediately in front of the strictured membranous portion; and (2) preventing the filiform from doubling upon itself.

To meet these conditions a tube about one-quarter of an inch in diameter was constructed, which could be passed down into the bulbous portion of the urethra. Inserting a filiform into this we were able, by moving the outer portion of the tube (Fig. 1, No. 2), to bring the point of the filiform to various places in the indurated mass, in which lay the lumen of the membranous urethra. Finally, by depressing the outer portion, and thus searching the superior surface of the urethra, the lumen was engaged by the filiform (Fig. 1, No. 3), which, without much difficulty, passed through the prostatic urethra into the bladder. The small tube had effectively prevented the filiform doubling back upon itself. Removing the tube, a curved steel following sound (LeFort) was at-

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tached to the filiform and pushed on into the urethra. It was then discovered that the filiform had again doubled upon itself, thus making it impossible to carry the sound through the strictured urethra. The follower was removed, the tube reinserted, and a flexible bougie follower (Fig. 1, No. 3) was attached to the filiform, which was small enough to pass down the tube. No difficulty was then experienced in pushing this flexible bougie, led by the filiform, through the strictured area into the bladder. The tube had effectively prevented the filiform from buckling.

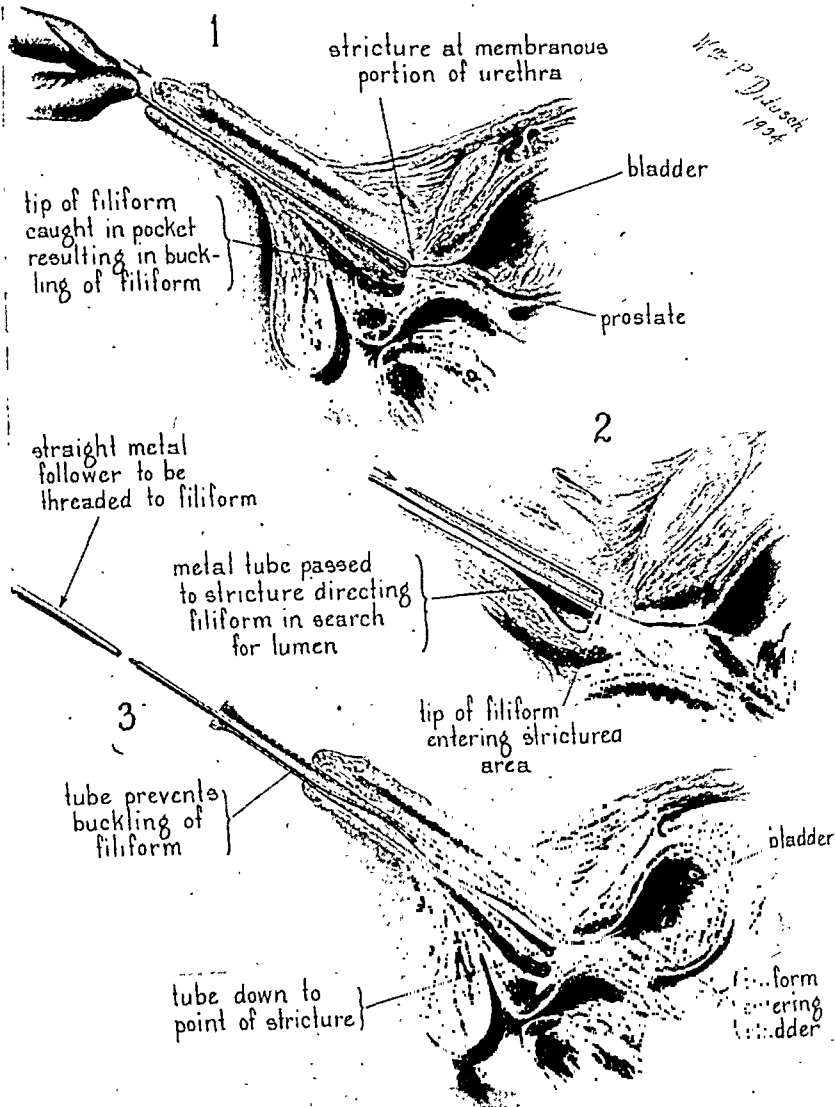


FIG. 1.—Case 1. (1)—Conditions present in a case of pronounced stricture of the anterior, prostatic and membranous urethra after operation for rupture of the urethra. The urethral lumen in the strictured area was small and eccentric. The tip of the filiform engaged in a pouch near the floor of the urethra and the filiform doubled upon itself, as shown. (2)—Use of Young's urethral tube to assist the filiform in searching for the lumen of the urethra, which was finally engaged. (3)—Use of urethral tube to prevent buckling of the filiform while the attached bougie is passed down the tube.

Having thus succeeded in introducing a No. 12 flexible follower bougie into the bladder, a series of tubes were then made (Fig. 2). These varied from No. 16F to 28F in size. Filiforms were first tried alone, but they again doubled upon themselves, and it was impossible to determine whether they had actually entered the strictured urethra or simply engaged in some pouch or false passage in the bulbous urethra. By means of the small tube, which had previously been employed, the proper orifice was

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located, the filiform passed into the bladder, followed by a flexible bougie, which was withdrawn, unscrewed from the filiform, the tube removed, a larger one inserted, and another bougie of greater caliber successfully passed through the strictured urethra into the bladder. Using this method at intervals of two to three days, it was soon possible to dilate the urethra up to about No. 20F by means of flexible bougies. When a larger, flexible bougie was used, too great resistance was encountered to force it through the strictured area. Accordingly, metal bougies, without a curve, were made (Fig. 3), which were practically identical with the flexible bougies. One of these instruments, when attached to the filiform (Fig. 1, No. 3), passed easily down an urethral

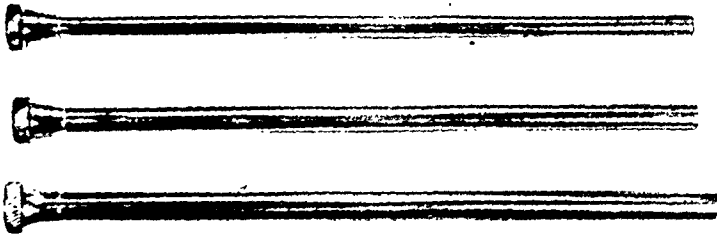


FIG. 2.—Young's urethral tubes to guide filiforms through strictured lumina and prevent buckling of filiforms.

tube until the filiform had gone entirely through the bulbous urethra (Fig. 4, No. 2). The urethral tube was then removed, and the straight metal bougie carried through the strictured area into the bladder (Fig. 4, No. 3). The fact that it was straight seemed to make no difference, the filiform itself furnishing the necessary curve to lead it over the median portion of the prostate into the bladder. In the subsequent treatment of this case, these straight metal bougies were successfully used up to No. 26F, and, although the fibrous mass in the perineum was very resistant, no great difficulty was encountered in pushing them on into the bladder. The filiform was in no case bent

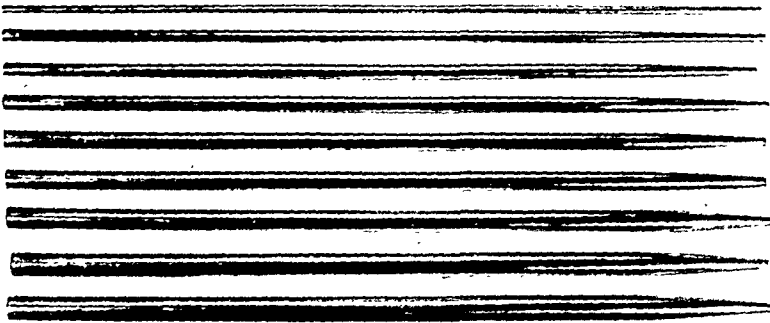


FIG. 3.—Young's straight metal followers attachable to filiforms, and used with or without the urethral tubes to dilate difficult strictures of the anterior urethra, and also very bad strictures of the prostatico-membranous urethra. These followers are now made with the outer end conical, without a screw hole for use without filiforms, particularly after hypospadias operations.

or broken. We are confident that the force employed was exercised with much greater safety than could have been used with the curved metal follower. The use of cystoscopes, urethroscopes and instruments for resection has taught us that it does not require much, if any curve, to go into the bladder. We have long been of the opinion that there was danger in the use of the markedly curved metal dilators, which we have employed in the past.

Owing to the roughened condition of the strictured area, and the greatly dilated bulbous urethra, it was never possible to do without the tubes, which were necessary to prevent the buckling of the delicate filiform.

Case 2.—A severe stricture of the membranous urethra was present, which followed a double sphincter plastic operation for the cure of incontinence. Filiforms engaged, but would not pass, forming several loops in the capacious bulbous urethra. During these manipulations, it was thought at one time the filiform had gone well through into the bladder, and the steel dilating follower was attached. As it would go no farther, it was withdrawn and it was then found that the filiform had broken. Bleeding indi-

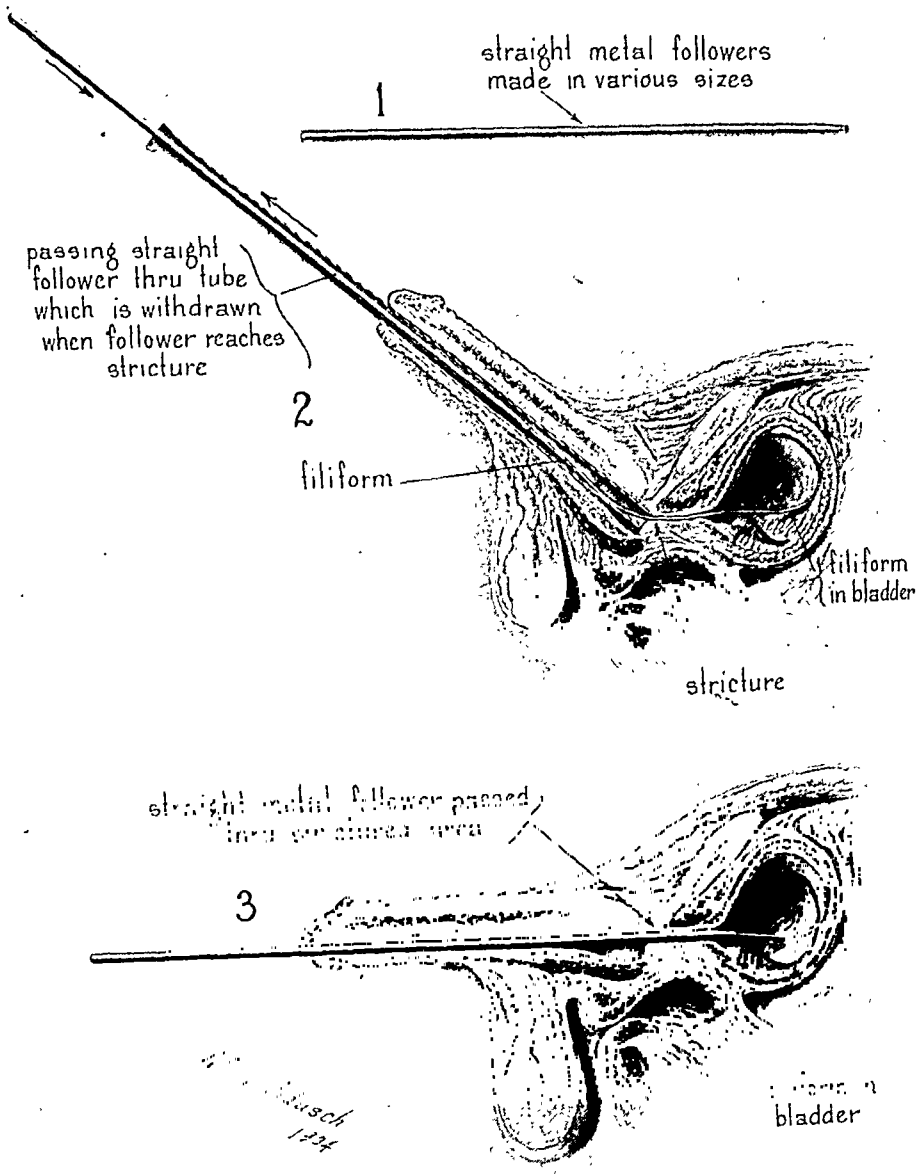


FIG. 4.—Case 1. (1)—Young's metal followers. (2)—The metal tube is being used to prevent buckling of filiform, but is removed when the follower reaches the stricture, in order to facilitate the deeper passage of the follower. (3)—Follower passed through stricture.

cated that the urethra had been traumatized, producing a pouch, or small passage, as a result of the doubling of the filiform. After a few days the urethral tubes shown in Fig. 3 were again used. No difficulty was experienced in finally discovering the orifice through which the filiform passed easily into the bladder, supported as it was by the tube which prevented its doubling. Dilating bougies, which were attached to the filiform, were also passed in this case with increasingly larger tubes to prevent doubling of

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the filiform, and little difficulty was experienced in bringing the urethra practically to normal size by the use of this technic. After a time the strictured urethra became so much softer that filiforms and ordinary metal followers could be employed, and ultimately sounds passed consecutively at intervals during the succeeding months. As a result of this treatment, it was possible eventually to dispense with dilatations. The patient had a normally functioning urethra, and was cured of his incontinence.

In such cases it is important not to proceed too rapidly. To cure these patients one must excise all except a small portion of mucosa in order to draw the periurethral muscle (sphincter) into tight contact after excising

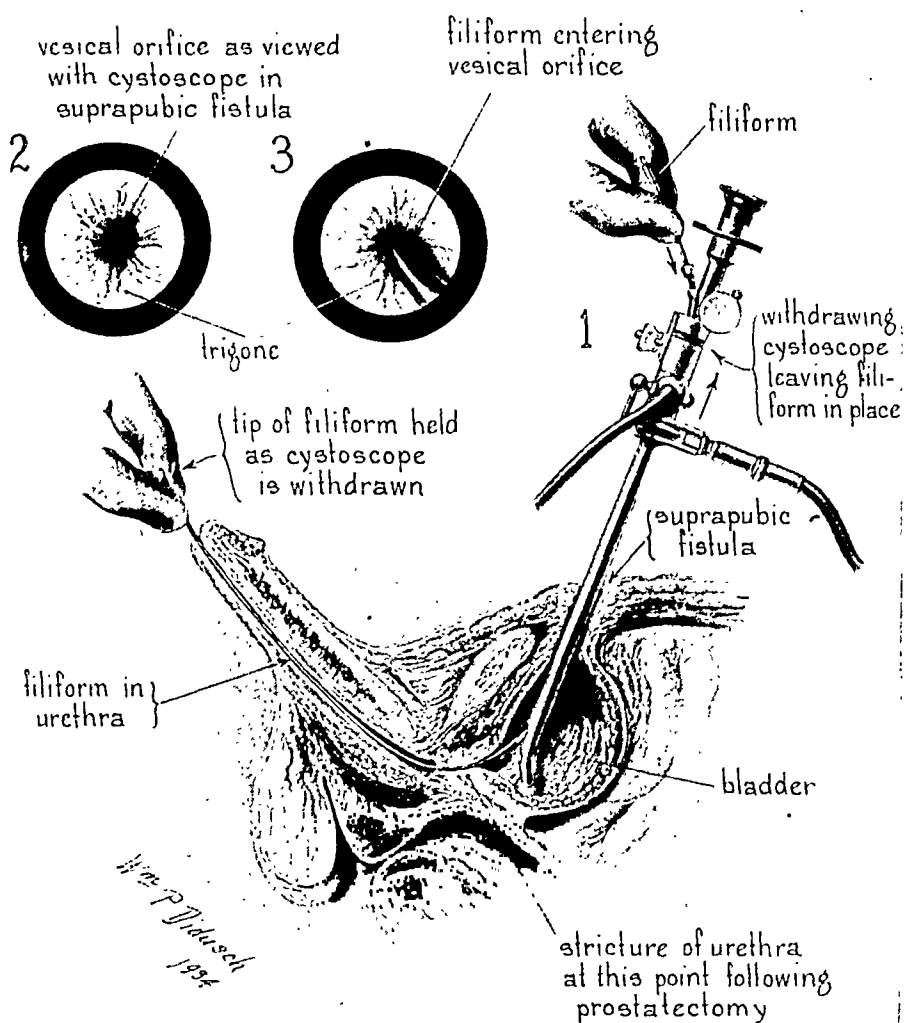


FIG. 5.—Retrograde passage of filiform through catheterizing cystoscope passed into bladder through suprapubic fistula.

the scar tissue (remaining after transurethral resection, or an improperly performed perineal or suprapubic prostatectomy). In other words, it is necessary to produce a stricture to cure the patient. This must be very cautiously dilated to avoid a rupture, which would impair the newly made sphincter.

The set of urethral tubes, above described, has been used successfully now in various types of cases, particularly those in which strictures were deep seated, eccentric, or surrounded by pockets in which filiforms would engage. Support given the delicate filiforms by the tubes effectively prevents doubling

of the filiform, both during the passage through the stricture into the bladder, and subsequently while conducting a follower to the deep urethra and through the sphincter. Judging by our experience, these tubes should prove a valuable addition to the armamentarium of stricture therapy.

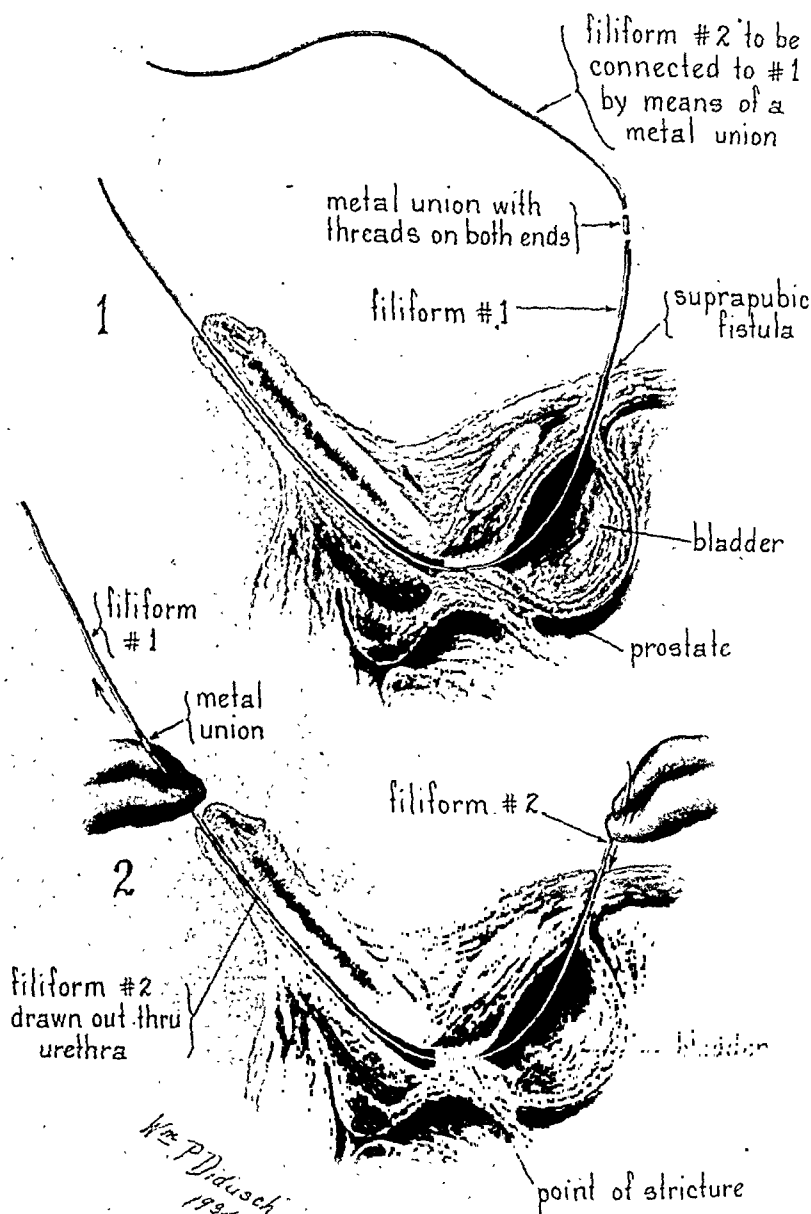


FIG. 6.—(1)—A second filiform is being attached to the one that has been introduced through the suprapubic fistula out through the urethra by means of a metal coupler. (2)—The second filiform is drawn out through the fistula and urethra until the butt end appears at the meatus, when it is detached from the first filiform.

THE USE OF THE CYSTOSCOPE TO PASS INSTRUMENTS, RETROGRADE, FROM THE
BLADDER THROUGH STRICTURES OF THE PROSTATIC OR
MEMBRANOUS URETHRA

In cases that have been subjected to operations upon the membranous or prostatic urethra (operations for rupture of the urethra, double sphincter

operations for incontinence, epispadias with incontinence, *etc.*) before devising the urethral tubes above described, we occasionally made use of a cystoscope introduced through the suprapubic wound (Fig. 5, No. 1), to pass filiforms through the strictured urethra. In such a case we have usually employed a filiform with a ureter catheterizing cystoscope. After locating the urethral orifice (Fig. 5, No. 2) no difficulty was experienced in passing the filiform into the prostatic urethra (Fig. 5, No. 3) and in the majority of cases it would also pass retrograde on through the strictured area and out the meatus, where its point was caught by an assistant. Withdrawing the cystoscope, and catching the screw end, which projects a short distance

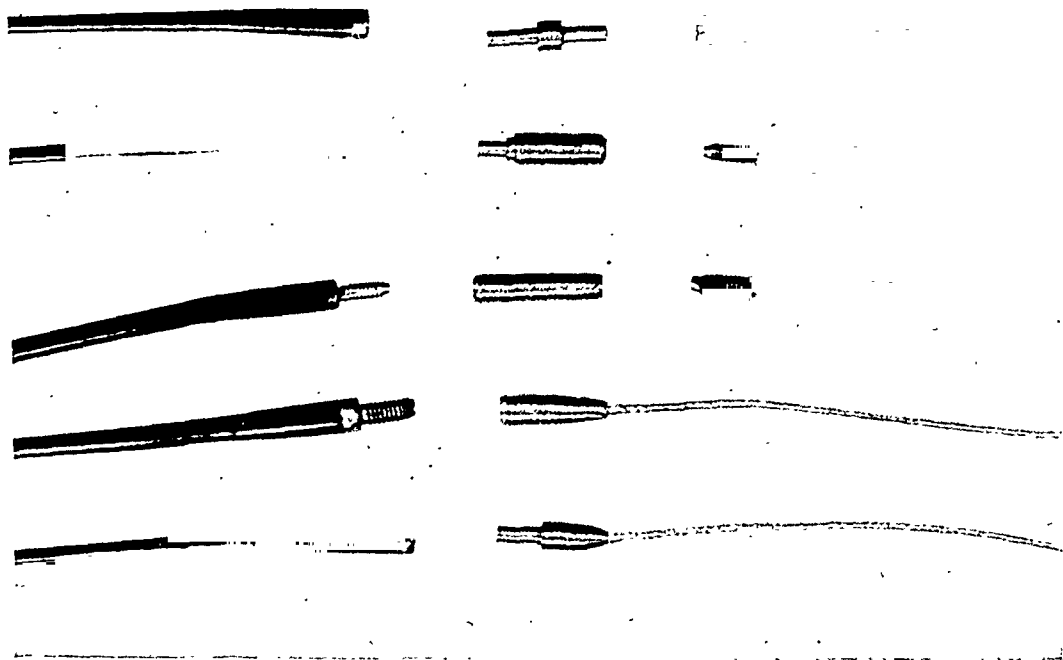


FIG. 7.—Various filiforms and different types of couplers necessary to connect them. In two lower photographs, a coupler attaching a thread or silkworm gut to filiform is shown.

from the suprapubic fistula, one was confronted then with the problem of passing dilating followers through the strictured area. By screwing a dilating bougie onto the filiform, and making traction upon it, the dilator was pulled and pushed through the suprapubic wound, and the strictured area out to the meatus. No metal instrument could be used for this.

At other times retrograde passage of a dilating bougie is not satisfactory, as not enough pressure can be exerted upon the flexible bougie. It is then desirable to attach another filiform to the one passed retrograde, thus fastening the butt ends together (Fig. 6, No. 1) by means of a coupling tube, so that the second filiform can be drawn out until its screw end projects from the meatus. The operator is careful to hold onto the pointed end, so as to prevent its escaping into the bladder (Fig. 6, No. 2). Dilating fol-

lowers are then attached to the filiform, and, by combined pushing and traction, are carried through the strictured area one after another until sufficient dilatation is accomplished. In our armamentarium are dilators which carry various types of filiforms (some male, some female, some with small and others with a large thread) so that in practice it has been found necessary to have screw couplers, with which every type of filiform can be attached to

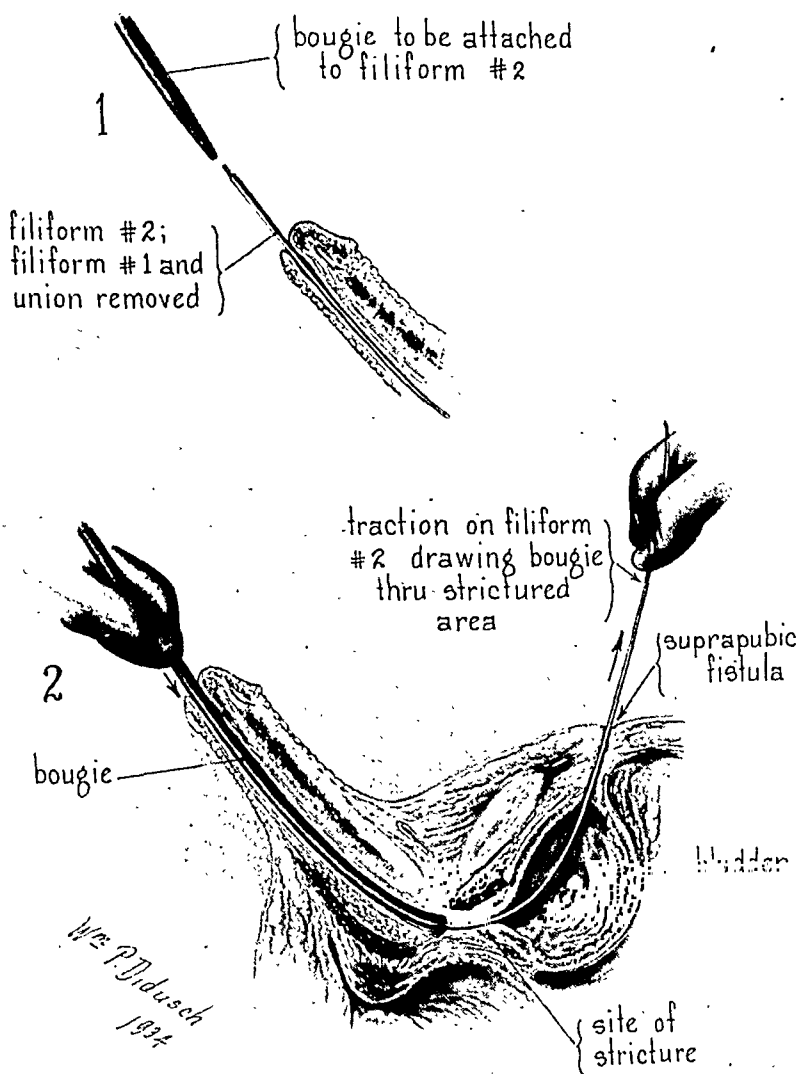


FIG. 8.—(1)—Flexible bougie is being attached to the second filiform, which has been drawn through the suprapubic fistula. (2)—Method of passing the flexible bougie by combined traction and pushing.

every other one. Some of these combinations are depicted in Figs. 7 and 8. With these simple screw couplers, no difficulty is experienced in passing filiforms and followers of various types through the urethra and out of suprapubic drainage fistulae (Fig. 8).

The use of the cystoscope to pass filiforms retrograde through a stricture in the urethra is troublesome, difficult and occasionally unsatisfactory. It is,

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therefore, desirable, when one has succeeded in passing filiforms to dilate strictures, to leave a thread in the urethra to avoid having to employ the cystoscope at the next treatment. This thread must be drawn through the urethra by the filiform when it is removed. To accomplish this, we have

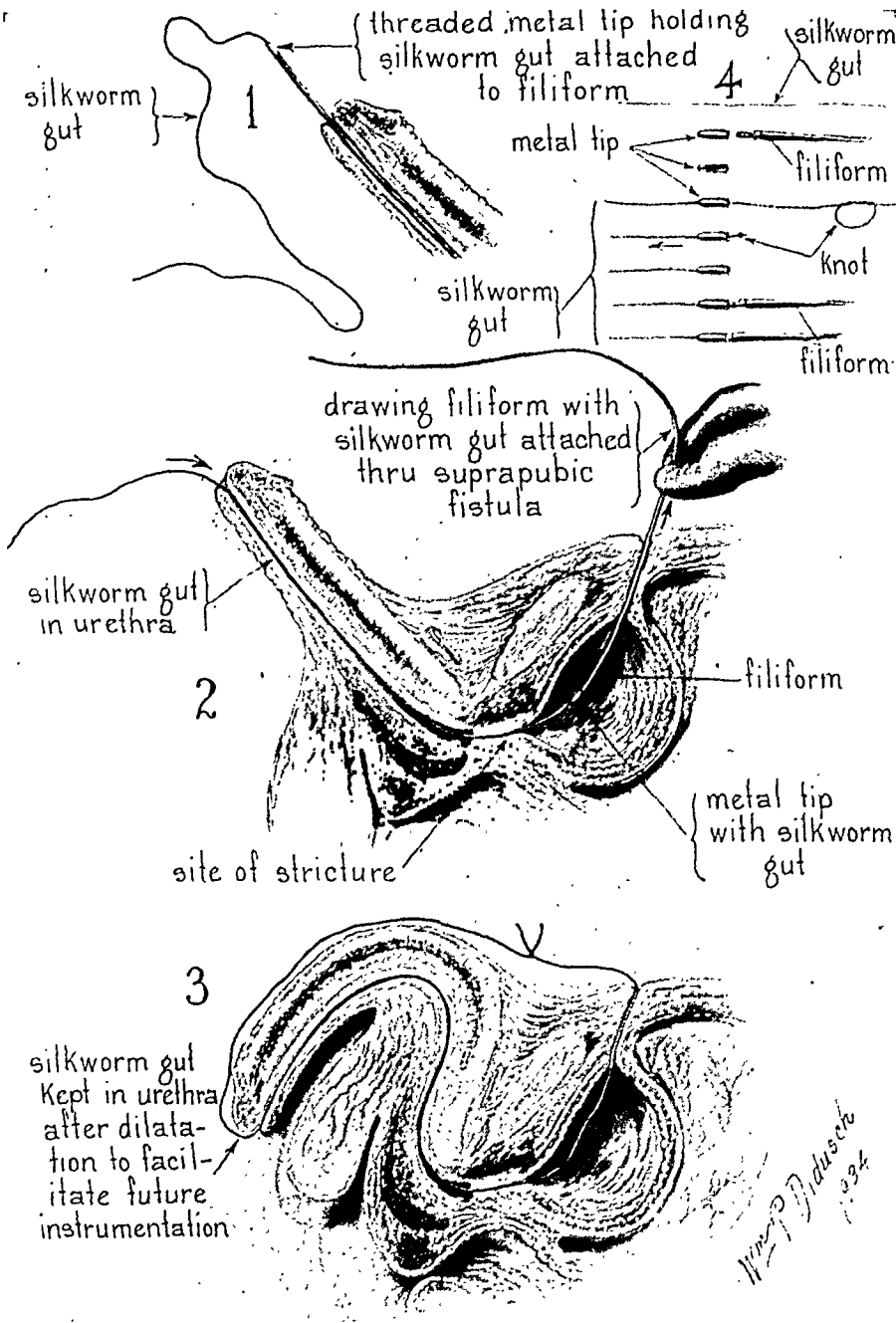


FIG. 9.—(1)—Attaching thread to filiform by conical coupler. (2)—Drawing thread through urethra, bladder and suprapubic fistula. (3)—Silk thread or silkworm gut left in place to facilitate passage of filiform next time. (4)—Method of attaching silkworm gut to conical coupler and then coupler to filiform.

had made a conical connecting piece through which the thread may be passed, knotted, attached to the filiform (Fig. 9, No. 1) and then drawn through the meatus and out the suprapubic fistula by the filiform (Fig. 9, No. 2). The urethral and vesical ends are then tied together so as to prevent escape (Fig. 9, No. 3). Braided silk threads are usually employed, but as these

have a tendency to accumulate calcareous deposits, we have more recently used a silkworm gut, which has no such drawback. In order to attach the silkworm gut, it is simply introduced through the coupling piece, bent firmly together, pulled out until a small loop remains, a bit of loose cotton placed in the loop to prevent its being drawn through when traction is made. By this method (Fig. 9, No. 4), silkworm gut can be used to draw filiforms through the strictured urethra for subsequent dilatations. A knot can also be used.

POSTOPERATIVE URETHRAL DILATATIONS

We now, after plastic operations in which dilatations must soon be carried out, leave a fine thread of silkworm gut in place. It remains there

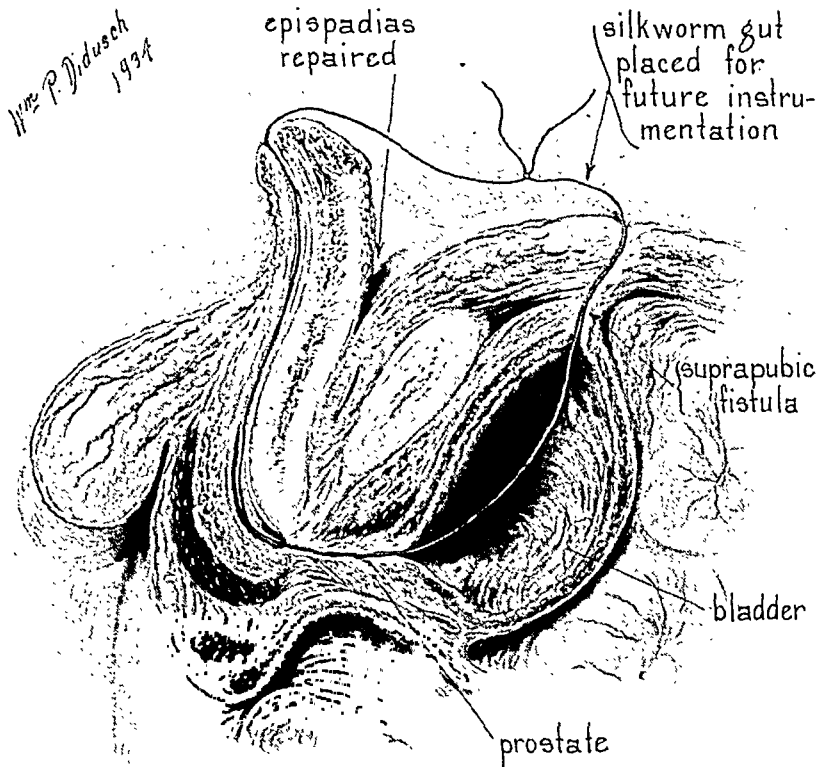


FIG. 10.—Suture still in place after withdrawing suprapubic drainage tube in a case of Young's double sphincter and penile plastic operation for epispadias.

until some three to four weeks after the operation, when the first dilatations with filiforms and bougies are to be undertaken. Fig. 10 shows a case of epispadias with incontinence, in which a double sphincter and penile plastic operation was carried out. The silkworm gut left in place emerges from the meatus and from the suprapubic wound. Some three to four weeks later it is employed to draw a filiform through, and this is followed by gradual dilatations with flexible bougies, and, in some cases, metal dilators. The same method is employed in the double sphincter operation for incontinence,

after transurethral resection, or prostatectomy. In cases of hypospadias, the passage of filiforms and followers after the operation may often be the cause of serious injury and breakdown of the sutured wound. By leaving a silkworm gut in the newly made urethra (Fig. 11), one end emerging from the perineal wound, and the other from the newly made meatus in the glans, several dilatations with filiforms and small followers can be ultimately carried out without danger or difficulty.

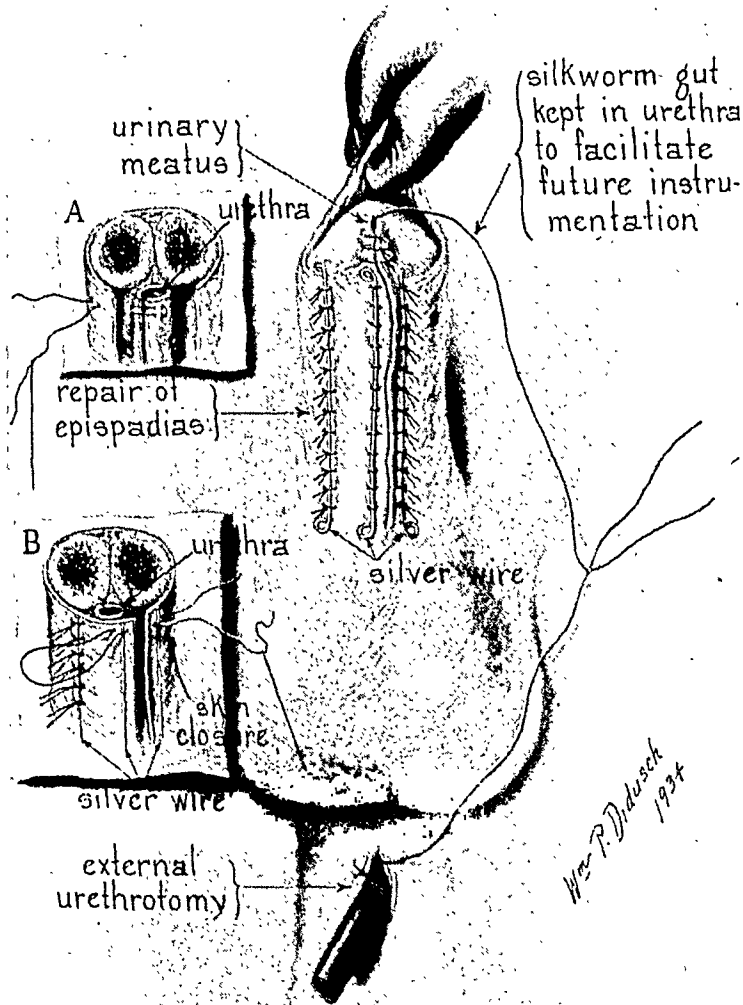


FIG. 11.—Thread left in place after completion of hypospadias operation by latest technic with use of silver wires: (A)—formation of urethral tube; (B)—covering urethral tube with penile skin (overlapping method).

CONCLUSIONS

Not infrequently after various operations upon the urethra, necessitated by traumatism, inflammatory strictures, incontinence or congenital defects (epispadias, hypospadias, *etc.*) one must pass dilating instruments. The passage of filiforms through the dense stricture is often extremely difficult, particularly as they have a tendency to buckle upon themselves and prevent the passage of a dilator; in fact, the attempt to pass a dilator may often

lead to severe traumatism, the operator not realizing that the filiform has buckled or broken. New instruments and technical methods have been described to obviate these difficulties, first a series of urethral tubes which facilitate the discovery of the urethral lumen in the strictured area, and which also prevent the buckling of the filiform when it and the attached, dilating follower are passed. The use of the catheterizing cystoscope to dilate a stricture of the deep urethra, by passing filiforms retrograde, has been described, and various technical devices for joining one filiform to another, or to attach a silk thread or silkworm gut, which is to be left in place to conduct other filiforms through the strictured region at subsequent treatments, have been depicted. By means of these simple mechanical devices, the postoperative care of various urologic operations has been rendered much more accurate and satisfactory.

RECTAL STRICTURE DUE TO LYMPHOPATHIA VENEREUM*

A CLINICAL AND PATHOLOGIC STUDY OF SIX CASES OBSERVED AT NECROPSY

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THE application of the Frei test to cases of so called anorectal syphiloma by Frei and Koppel¹ in 1928 altered the ideas previously held on the subject of inflammatory rectal stricture. Prior to that time syphilis, gonorrhea and tuberculosis were universally believed to be the principal etiologic factors. Since then a considerable amount of clinical and experimental evidence has been collected to prove that lymphopathia venereum is responsible for a large majority of these cases, and an entirely new concept of stricture of the rectum has therefore arisen.

The evidence just referred to has recently been reviewed² in a report from Charity Hospital in New Orleans of 154 Frei-positive cases of lymphopathia venereum, including a detailed analysis of 58 cases of rectal stricture. New Orleans appears to be a veritable hotbed of the disease, being a seaport with a large Negro population. The number of patients admitted with inflammatory rectal stricture, the most frequent manifestation of lymphopathia venereum in the female, exceeds 100 in the course of a year. During the period 1911-1933, inclusive, 1,285 cases of rectal stricture were treated at Charity Hospital, not more than 10 per cent of which were obviously post-operative or neoplastic, and it seems safe to assume from the clinical data that the great majority of the remaining cases fall into the group under discussion. According to our evidence, rectal stricture accounts for approximately 70 per cent of the cases of lymphopathia venereum in women, whereas pudendal lesions and inguinal buboes together constitute not more than 25 per cent of the lesions in this sex. In a consecutive series of 83 Frei-positive tests in females recently reported,² eight cases exhibited inguinal buboes and 12 esthiomène or chronic elephantiasis of the vulva, whereas 57 had rectal stricture. Also included in this group were two patients with anal granuloma without stricture, two with granulomatous proctitis without stricture, and two with granulomatous lesions of the cervix uteri.

The type of inflammatory stricture due to lymphopathia venereum has been known to surgeons and dermatologists since its description by the Danish surgeon, Larsen,³ in 1849 as "hyperplastic infiltration of the rectum," and by Fournier⁴ in 1875 as "anorectal syphiloma." A comprehensive review of the subject may be found in the recent monograph of Stannus.⁵

The frequent involvement of the rectum by the virus of lymphopathia venereum is readily explained by the lymphatic drainage of the genitalia in the female, as demonstrated by Jersild,⁶ Barthels and Biberstein.⁷ As these

*The term lymphopathia venereum has been substituted for lymphogranuloma inguinale, in accordance with the newly adopted nomenclature.

investigators have emphasized, only a small proportion of the primary lesions in the female, those situated on the external labia or the clitoris, drain to the inguinal lymph nodes, in contradistinction to the male group, in which inguinal buboes are the rule. In the occasional instances of rectal stricture observed in male patients, either colored or white, a history may often be elicited of a primary anal lesion, following pederasty.

We have had the unusual opportunity during the past year of observing at necropsy six cases of rectal stricture, in three of which Frei-positive reactions were obtained during life.



FIG. 1.—Necropsy specimen (Case 1). Chronic ulcerative stenosing proctitis and periproctitis in rectal stricture of two to three years' duration, with positive Frei reaction.

CASE REPORTS

Case 1.—S. R., a Negro female, aged 30, had a history of rectal stricture and proctitis of at least two years' duration. For the last eight months she had complained of amenorrhea, a purulent discharge from the rectum, increasingly difficult bowel movements, and pain in both inguinal regions. Physical examination revealed a bulging mass in the anterior rectal wall, with ulceration of the rectal mucosa and draining sinuses

about the anus. The Wassermann reaction had been positive a year before admission, but was negative after treatment. The Frei test was positive. The clinical diagnosis was rectal stricture (lymphopathia venereum) with multiple fistulae in ano and hemorrhoids. Routine treatment was undertaken but the patient did not respond and died three months after admission.

Necropsy revealed a chronic ulcerative stenosing proctitis and periproctitis (Fig. 1). The cause of death was a superimposed acute ulcerative colitis involving principally the descending colon and sigmoid, with terminal cardiac failure.

The relevant portion of the protocol follows: The lowermost portion of the rectum, extending up from the anus about a finger's length, approximately 10 to 12 cm., is considerably thickened and indurated. The mucosa shows numerous small granulomatous tags, as well as several incomplete fistulae, and has an irregular, band-like, ribbed or corrugated appearance. This lesion ends abruptly in a stenosing, shelf-like formation which sharply demarcates the granulomatous tissue from the relatively uninvolved



FIG. 2.—Section of anal tag simulating hemorrhoid in case of rectal stricture. Note keratosis, chronic inflammation and numerous dilated lymphatics.

sigmoid above it. At the anus are several small fleshy or rubbery tags, varying in size from 1 to 3 cm. in diameter, and the adjacent perianal region shows several small areas of dimpling and scarring indicative of fistulae in ano.

Microscopic examination of the rectum shows the wall markedly thickened. The mucosa is ulcerated and infiltrated with small round cells, polymorphonuclear leukocytes, plasma cells, and histiocytes. There is a tendency to regeneration of the mucosa, with squamous metaplasia. The thickened submucosa shows a loose vascular connective tissue with areas of hyalinization and many tissue spaces, some of which are lined by a single layer of endothelial cells and have the appearance of dilated lymphatics. The muscularis is distinctly hypertrophied and presents extensive infiltration with nests of small round cells. The thickened and adherent perirectal fat and connective tissue show infiltration with small lymphocytes and plasma cells, fibroblastic proliferation, fibrosis and endarteritis with narrowing. Sections of the perirectal lymph nodes in the vicinity of the stricture present periadenitis and chronic nonspecific lymphadenitis, characterized by fibrosis and plasma cell infiltration. Section of an anal tag (Fig. 2) shows parakeratosis, keratosis, fibrosis of the corium and subcutaneous tissue, and, in places, a loose,

edematous granulation tissue extensively infiltrated by plasma cells. Numerous dilated lymphatics are also in evidence.

White mice were inoculated with infected tissue emulsion prepared from fragments of the rectal mucosa, regional lymph nodes and fistulous tracts. The mice injected intraperitoneally showed no evidence of infection, while those inoculated intracerebrally developed suppurative meningitis.

Case 2.—J. A., a Negro female, aged 37, had received hospital treatment seven years previously for the rectal stricture which she presented on admission. She had cardiac decompensation at this time, and was incontinent and psychotic. Physical examination revealed a rectal stricture admitting one finger, a rectovaginal fistula, anal tags, and several fistulae in ano. The labia were markedly enlarged and indurated. There were draining sinuses in both inguinal regions and deep, infected decubitus ulcers over the sacrum. The Wassermann reaction was positive and the Frei test negative.* The patient was in extremis when observed and died several days later of cardiac failure.

Anatomic Diagnosis.—Chronic stenosing proctitis and periproctitis with multiple fistulae; chronic ulcerative vulvitis and vaginitis with secondary infection; rectovaginal fistula; multiple infected decubitus ulcers over the sacrum; dilatation of the heart; pulmonary congestion and edema; anasarca; severe fatty change of the myocardium and liver; chronic and acute infectious splenic swelling; luetic mesaortitis with saccular dilatation of the ascending arch.

The relevant portion of the protocol follows: The loop of terminal ileum just proximal to the ileocecal junction is adherent to an inflammatory mass about the sigmoid, and communicates with the latter by a fistulous opening. At this site, there are also several fistulae of the sigmoid leading into the surrounding inflammatory tissue. In the ascending colon there is an oval, shallow ulcer, with a red, sharp border, measuring about 2 cm. in diameter. The remainder of the bowel shows nothing significant except for the sigmoid and rectum, which are the site of a peculiar granulomatous stenosing lesion, approximately 45 cm. in length. The thickened rectal mucosa shows tag-like, edematous papillary excrescences. The indurated wall of the rectum and sigmoid is surrounded by a thick mass of inflammatory fat and connective tissue, into which multiple fistulae extend from the mucosa. There is an area of constriction in the sigmoid, several centimeters above the rectosigmoid junction. There is another area of stenosis in the lowermost portion of the rectum, where the lumen is narrowed for a distance of approximately 10 cm.

The vulva is diffusely thickened and enlarged. The clitoris, the pudenda and the perirectal tissue show induration, multiple granulomatous tags, and secondary infection with ulceration. About 2 cm. from the vaginal orifice there is a large rectovaginal fistula. The vaginal fornix shows a shallow, ulcerated area about 2 cm. in width. There is also a small, red, ulcerated lesion on the cervix about 0.5 cm. in diameter. The uterus shows no significant change, but the adnexa are buried in dense pelvic adhesions.

Histologic sections show extensive secondary infection and postmortem change, but it is evident that the chronic inflammation in the rectum, sigmoid, vulva, vagina, and other structures is nonspecific in character. No plasma cell reaction is noted, nor any endarteritis or endophlebitis suggestive of luetic granuloma. The tissues were obtained too long after death to permit of animal inoculation.

Case 3.—C. M., a Negro female, aged 29 years, was admitted with a diagnosis of pulmonary phthisis and hypertensive heart disease, the diagnosis being based on the history of productive cough, loss of weight, dyspnea and edema of the ankles of two to three months' duration. She appeared acutely ill; the temperature was 101° F., and

* It is pertinent in connection with this case to cite the reminder of Cole, that in certain instances of prolonged illness and lessened general resistance, there may be an allergy, and his warning that in such cases lymphopathia venereum should not be ruled out on the basis of a single negative Frei reaction.

signs of focal consolidation were elicited in the right chest. Pelvic examination revealed a profuse vaginal discharge and adnexal tenderness. Because of the patient's serious condition, rectal examination was not made and the correct diagnosis was therefore not suspected until autopsy. Death occurred two days after admission.

Anatomic Diagnosis.—Chronic ulcerative stenosing proctitis and sigmoiditis with ileosigmoidal fistula; acute diffuse fibrinopurulent peritonitis; bronchopneumonia with serofibrinous pleuritis; luetic mesaortitis. The cause of death was peritonitis, probably

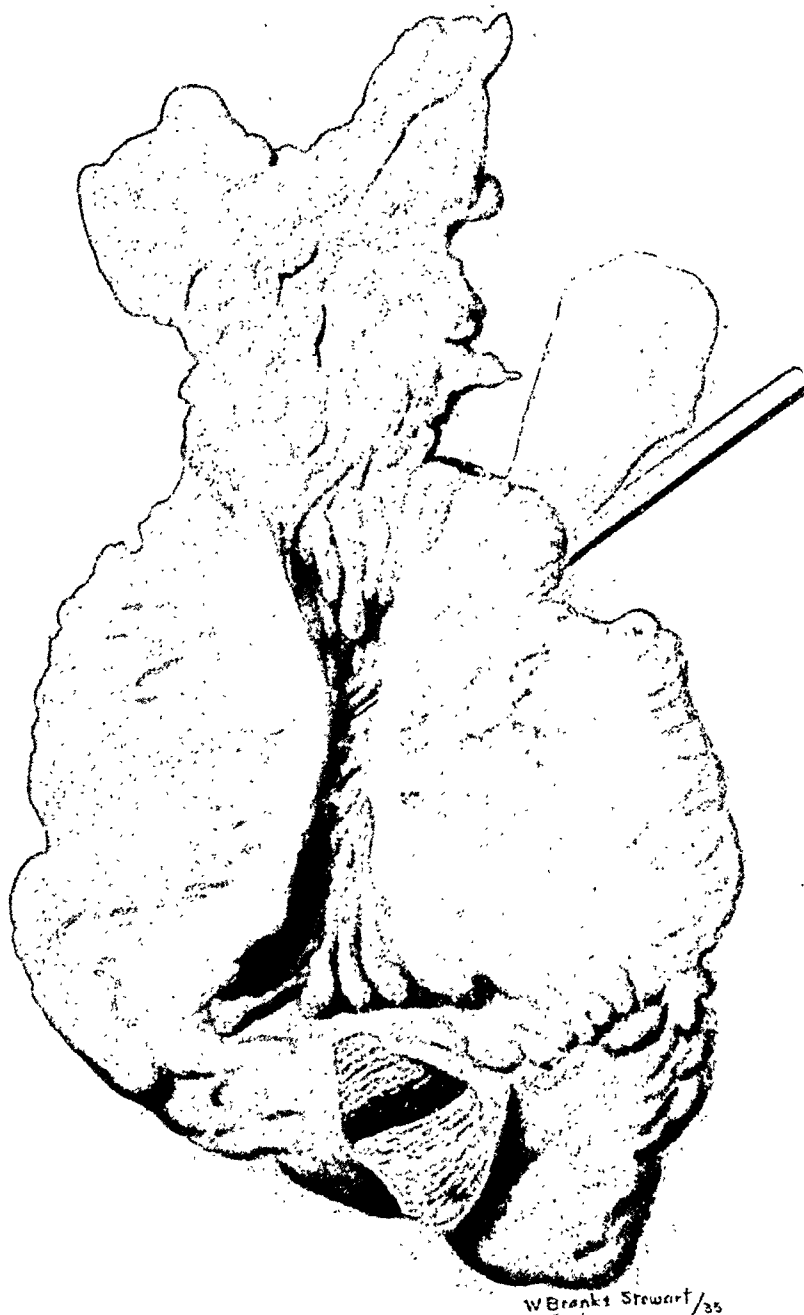


FIG. 3.—Necropsy specimen (Case 3). Chronic ulcerative stenosing proctitis and sigmoiditis with ileosigmoidal fistula.

due to perforation of the sigmoid, and it was inferred that the walling off of the perforation by a loop of ileum had resulted in an ileosigmoidal fistula. The lesion in the rectum and sigmoid is well illustrated in Fig. 3. The histologic study was unsatisfactory because of postmortem change, and the material was too old for animal inoculation.

Case 4.—B. S., a Negro female, 29 years old, had been seized with upper abdominal pain, preceded by dizziness and syncope, six days before admission. The pain, together

with distention and tenderness, had persisted since that time, and bowel movements had been scanty in spite of the free administration of purgatives. Persistent vomiting had developed, and the whole story was compatible with the admission diagnosis of rectal stricture, with intestinal perforation and low-grade peritonitis. Rectal examination showed a stricture approximately 3 cm. above the anal orifice, barely admitting the tip of the little finger. Roentgenologic examination of the abdomen revealed numerous fluid levels and air under the right leaf of the diaphragm. The patient's condition did not warrant surgical intervention, and death occurred on the fourth day after admission.

Anatomic Diagnosis.—Chronic ulcerative granulomatous proctitis with marked stenosis; rectovaginal fistula and multiple fistulae in ano; ulcers of the sigmoid with perforation and diffuse peritonitis.

The relevant portion of the protocol follows: The peritoneal cavity contains a large amount of yellowish, purulent fluid and fecal material. The descending colon and sigmoid are distended, hypertrophied, and filled with stone-like fecal masses. A small area of perforation in the sigmoid has allowed the entrance of fecal material into the peritoneal cavity. The hypertrophied mucous membrane at this site shows multiple deep ulcers due to pressure by impacted fecal masses. The rectum is distended and the wall of the ampulla is markedly thickened and indurated. Three centimeters above the anus there is a narrowing of the rectal lumen with marked fibrosis of the perirectal tissue. The mucous membrane of the rectum shows scar formation and several fistulae which extend into the perirectal fat tissue. At this site there is also a large rectovaginal fistula. The gross specimen is illustrated in Fig. 4. The histologic study was unsatisfactory because of postmortem change, and for the same reason animal experiments were not undertaken.

Case 5.—H. N., a Negro female, aged 29 years, sought hospitalization for the treatment of fistulae in ano and pellagra. She complained of a burning tongue, diarrhea, and discoloration and itching of the hands, all the symptoms being of three months' duration. Physical examination revealed a rectal stricture 4 cm. above the anus, barely admitting the index finger, together with "hemorrhoids" (anal tags) and induration of the rectovaginal septum. The rectum below the stricture was irregularly thickened. The temperature ranged to 102° F. Both the Wassermann and the Frei reaction were positive. The clinical diagnosis was pellagra and rectal stricture due to lymphopathia venereum. Despite an appropriate diet to combat the pellagra, the patient's diarrhea remained intractable, dementia developed, and she died two months after admission. Necropsy was performed six days later.

Necropsy revealed a chronic ulcerative granulomatous proctitis, with annular stricture, a severe secondary proctitis, periproctitis, anal tags and fistulae in ano. The symmetrical dermatitis of the hands and feet was typical of pellagra. The other significant findings included extreme fatty change of the liver, chronic infectious splenic swelling, and chronic salpingitis with adhesions. The cause of death was considered to be pellagra, with rectal stricture due to lymphopathia venereum as the contributory factor.

The relevant portions of the protocol follow: The ascending colon shows marked atrophy, and the sigmoid, polypoid thickening with small areas of ulceration. The wall of the rectum is markedly thickened and indurated, and the lowermost segment extending approximately 5 cm. above the anus shows marked stenosis. The mucous membrane at this site presents marked atrophy with numerous ulcers and incomplete fistulae extending into the indurated perirectal fat and connective tissue. The gross specimen is illustrated in Fig. 5.

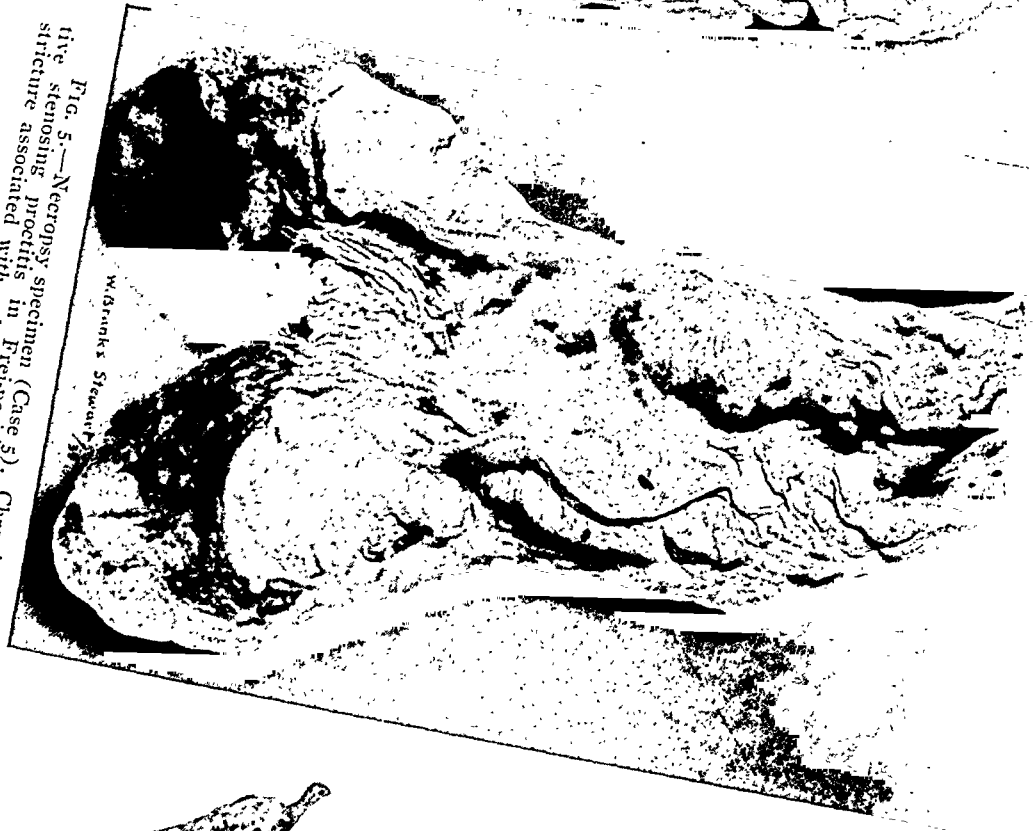
Histologic examination of the rectum shows a chronic nonspecific proctitis with superimposed acute inflammation. Postmortem change is too advanced, however, to permit detailed study. Sections of the enlarged perirectal, lumbosacral and inguinal lymph nodes indicate a chronic lymphadenitis characterized by numerous plasma cell

Fig. 4.—Necropsy specimen (Case 4). Chronic ulcerative granulomatous proctitis with marked stenosis. Note rectovaginal fistula.



Dranks & Stewart/35

Fig. 5.—Necropsy specimen (Case 5). Chronic ulcerative stenosing proctitis in Frei-positive case of rectal stricture associated with pellagra.



W. Dranks & Stewart/35

Fig. 6.—Necropsy specimen (Case 6). Chronic ulcerative stenosing proctitis and sigmoiditis in Frei-positive case of rectal stricture, associated with pellagra.



nests. The skin shows conspicuous atrophy of the epidermis, as seen in the late stage of pellagra. The remaining organs show no significant change.

Case 6.—K. S., a Negro female, 36 years of age, had had a rectal stricture dilated during a previous admission to the hospital. The present admission was for treatment of pellagra, manifested by a sore, red tongue and a typical symmetrical dermatitis of the hands and feet. Rectal examination revealed a stricture of mild degree situated 4 cm. above the anus. The Frei reaction was positive, the Wassermann reaction negative. In addition to her stricture the patient presented a very large granulomatous lesion extending from the mons veneris to the anus; its appearance suggested granuloma venereum, and it improved following the intravenous administration of tartar emetic. The clinical diagnosis was pellagra, rectal stricture due to lymphopathia venereum, and granuloma venereum of the pudenda. The patient had a brief remission and then despite an appropriate antipellagra diet and continued dilatation of the rectal stricture, she became progressively weaker and more emaciated, gluteal bed sores appeared and dementia developed. Approximately ten months after the first admission she died as a result of pellagra, with rectal stricture as the contributory factor.

Anatomic Diagnosis—Lymphopathia venereum with rectal stricture, pellagra, and granuloma venereum of the vulva. The significant findings follow: The rectum shows marked thickening of the wall with resulting stenosis of the lumen commencing at a point 4 cm. above the anus and extending for a distance of approximately 10 cm.



FIG. 7.—Polypoid mucosa of rectum showing dilated lymphatics with perilymphangitis.

This lesion is sharply demarcated from the proximal uninvolved mucosa of the sigmoid. The mucous membrane of the stenosed area is scarred and extensively ulcerated. The perirectal tissue shows extensive fibrosis with numerous adhesions between the rectum, uterus and adnexa. The fallopian tubes are thickened. The vulva is indurated, hypertrophic and shows the extensive depigmentation seen in treated cases of granuloma venereum. The iliac and retroperitoneal lymph nodes are enlarged. The gross specimen is illustrated in Fig. 6.

Histologic examination of the rectum reveals postmortem change too far advanced to permit detailed examination. The enlarged inguinal, lumbosacral and periaortic lymph nodes show chronic nonspecific lymphadenitis. Sections of the involved portions of the skin present the late atrophic stage of pellagra.

This was the third Frei-positive case followed to necropsy and emphasizes, as does Case 5, the frequent association of rectal stricture and pellagra.

COMMENT.—From the foregoing discussion it is evident that one may now separate from the chronic granulomata of the rectum and sigmoid another clinical and pathologic entity, *i.e.*, chronic ulcerative stenosing proctitis and periproctitis, the etiology of which is not syphilis, as has hitherto been incorrectly assumed, but lymphopathia venereum. This condition, recognized as early as 1897 by Kaufmann,⁸ is described with uncertainty as to the

etiology, but otherwise in terms that might well be applied to the type of rectal stricture with which this paper is concerned. It cannot be denied categorically that an occasional rectal stricture may be luetic in origin, but the diagnosis of luetic stricture should be reserved for those rare cases in which an actual gumma is demonstrated in the mucosa or submucosa of the rectum.

Pathologic material obtained by biopsy, surgical resection and necropsy shows no specific inflammation indicative of syphilis, but rather a type of chronic inflammation resulting from lymphatic involvement, apparently common to all lesions of lymphopathia venereum. These manifestations occur in the pudenda as well as in the rectum, and they have also been observed in the scrotum and penis in cases of elephantiasis following total excision of infected inguinal nodes, as noted by Barthels and Biberstein.⁷ These investigators have also described the lesions occurring in rectal stricture, as observed in two surgically resected specimens and three additional biopsies from patients with inflammatory rectal stricture and positive Frei reactions. The histologic findings may be briefly summarized as follows: destruction and ulceration of the mucosa, with a tendency upon regeneration to squamous metaplasia; infiltration and disruption of the muscularis by focal miliary accumulations of leukocytes and plasma cells, with subsequent fibrosis; dilatation of the lymphatics, with perilymphangitis and endolymphangitis; marked endarteritis and narrowing of the blood vessels, as in any chronic inflammatory lesion. The indurated perirectal fat and connective tissue likewise show perilymphangitic and perivascular infiltration. These observations were confirmed by Wien, Perlstein and Neiman,⁹ who reported two Frei-positive cases of rectal stricture followed to necropsy. The features enumerated above appear to be constant and we have repeatedly observed them in our biopsy and necropsy material (Fig. 7). It may be emphasized at this point, that rectal or anal biopsy should always be supplemented by the Frei test, since biopsy alone scarcely enables one to make a diagnosis more definite than chronic inflammation suggestive of lymphopathia venereum.

The pathologic process is progressive and is not necessarily confined to the rectum; in severe cases, as Kaufmann⁸ was well aware, it may extend to the sigmoid. When this occurs, there is a tendency to fistulae between the sigmoid and adherent loops of small intestine, as observed in two of our necropsies. In Case 2, the sigmoid as well as the rectum was involved and an ileosigmoidal fistula had developed. In Case 3, an ileosigmoidal fistula was also encountered, apparently as a result of walling off of a sigmoid perforation, too late, however, to avoid peritonitis.

This series of necropsies serves to illustrate some of the complications to which patients with inflammatory rectal stricture are subject. In Cases 1 and 2, death was due to terminal cardiac failure, brought on in one instance by an acute ulcerative colitis and in the other by severely infected bedsores. In Cases 3 and 4, death was caused by peritonitis, in the latter instance as a result of a perforated decubitus ulcer of the sigmoid due to impacted fecal

masses above a tight rectal stricture. In Cases 5 and 6, the cause of death was pellagra, associated with severe secondary proctitis, which failed to respond to the usual therapy.

SUMMARY

(1) A clinical and pathologic study of six cases of rectal stricture due to lymphopathia venereum observed at necropsy within the period of one year is presented.

(2) Four cases were observed clinically and are among the few recorded instances of rectal stricture due to lymphopathia venereum which came to necropsy diagnosed as such. Positive Frei reactions were obtained in three of these cases.

(3) The findings clearly indicate that the advanced stage of involvement of the rectum by the virus of lymphopathia venereum is represented by the pathologic entity of chronic ulcerative stenosing proctitis and sigmoiditis, the etiology of which has hitherto been obscure.

(4) The most frequent manifestation of lymphopathia venereum in the female is rectal stricture.

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SUPPURATIVE ARTHRITIS OF THE SACRO-ILIAC JOINT

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SUPPURATION of the sacro-iliac joint is a clinical entity which occurs more frequently than is commonly believed. If this condition is kept in mind by the physician when an acute lesion of obscure etiology is encountered in the lumbar or gluteal regions with unilateral lower abdominal symptoms, the diagnosis would be made at a more favorable phase of the disease, with consequent earlier appropriate drainage and a better prognosis, as the mortality rate in this lesion is relatively high even if recognized early.

This disease is only occasionally mentioned in text-books on surgery, and then by name only; no adequate description of the condition was found. Jones and Lovett do not mention the sacro-iliac joint in discussing pyogenic infections of joints, nor does Campbell in his description of acute affections of joints. The fact that the prognosis is bad is mentioned,^{2, 6, 7} but no statistics are given. Such opinions regarding prognosis are probably based upon studies of tuberculosis of the sacro-iliac joint,⁹ a subject which has been thoroughly studied, and about which the literature is quite voluminous. Only a few articles in English on suppurative arthritis of the sacro-iliac joints could be found under that title. Poore¹¹ wrote an excellent article on this subject in 1878, and reported two cases of his own and collected 56 cases from the literature, mainly French. A number of articles were found under the title of "Psoitis."^{4, 6, 14, 15} The clinical picture described in these corresponded almost exactly with that found in our cases, leading us to believe that they were true suppurations of the sacro-iliac joint, but that only the secondary psoas abscesses were recognized. Young¹⁶ reported what was probably a true primary pyogenic infection of the sacro-iliac joint. The patient was treated by incision but the technic of the operation was not described.

During the past three years five cases have been diagnosed and treated by the author. Six other cases have been seen either in consultation or by courtesy of other surgeons. The first five cases are reported in some detail. Of that number, two have died, two are well, and one healed but is now again in the hospital with an acute exacerbation of osteomyelitis of the pelvis. After studying this group carefully we now feel that certain errors can be avoided, enabling one to make the diagnosis more readily and treat the lesion more efficiently.

Pathologic Anatomy.—Clarke⁴ gives an excellent description of the pathology in this lesion. His postmortem findings were somewhat similar to those found in Case 3 of our series, upon whom an autopsy was performed.

The disease may start within the joint itself, in the ilium, or sacrum adjacent to the joint. It would seem to be secondary to a blood stream infec-

tion, in as much as the clinical course is similar to pyogenic arthritis in other joints. In one instance in the series (Case 3), the primary focus was probably in the ilium, between the posterior superior and inferior spines, so that this case may possibly be considered as an acute arthritis complicating osteomyelitis of the ilium. In the other four instances no definite site could be precisely determined, but the symptoms were well localized over the sacro-iliac joint and in the iliac fossa of the abdomen in all five cases. At operation no free pus was found until the pelvic cavity was entered, in Cases 1, 2 and 4. In Case 3 no free pus was found although culture was positive from a suspicious looking area in the ilium, before entering the joint. It is difficult to state whether this represented the original focus of infection, or whether the disease had extended to this spot from the joint. Case 5 was not operated upon and autopsy was refused. All these patients had abdominal symptoms early in the disease. All roentgenologic evidence pointed to pathology in the sacro-iliac joint, even in Case 3. There was no evidence of osteomyelitis of the ilium or sacrum except at the joint surfaces before operation. Of course, they developed osteomyelitis of the ilium, sacrum, ischium, or all of them, later. For these reasons, we believe that these patients had a primary infection of the sacro-iliac joint rather than a secondary pyogenic arthritis following osteomyelitis of the ilium or other pelvic bones. Thus, they may be considered as primary acute pyogenic arthritides.

As soon as the sacro-iliac joint is involved, the pus under pressure, following the path of least resistance, quickly breaks through the anterior sacro-iliac ligament, which is very thin and easily ruptured.¹³ Sashin says that "the anterior sacro-iliac ligament is a thin, rather weak structure," and, "upon slight pubic separation it is stretched and very often tears."

What paths may the pus follow? Passing through this aperture, the pus from the joint burrows under the iliacus muscle and fills the iliac fossa. When this fossa is filled, the pus may take one of several courses:

(1) It may follow the tendon of the iliopsoas muscle, in which event it will become superficial on the inner aspect of the thigh.

(2) If at Poupert's ligament, instead of following the iliopsoas, it follows the pectineus muscle in cases with necrosis of intervening tissues, it will become superficial on the posterior aspect of the thigh.

(3) It may enter the hip joint through a bursa which is found between the iliopsoas tendon and the anterior part of the capsule of the joint, if the bursa communicates with the joint, as it sometimes does. One in this series took this pathway (Case 3).

(4) Should it follow the tendon of the obturator internus, which passes out of the pelvis through the lesser sacrosclatic foramen, the abscess will point behind the hip joint.

(5) If the pathway be along the course of the pyriformis muscle, which passes through the greater sacrosclatic foramen, a low gluteal abscess occurs.

(6) Should its course be upward from the iliac fossa into the lumbar region, a lumbar abscess forms.

(7) The pus may travel anteriorly and upward towards the crest of the ilium and break through anteriorly onto the abdominal wall.

When muscle planes have broken down, the pus follows very unorthodox pathways. The author has observed a penetration of the pelvic floor and discharge through the vagina in a tuberculous lesion of the sacro-iliac joint, and in one case of this series the rectal wall was eroded, and a rectal fistula produced. Goldman⁵ reports a case of blind internal fistula with arthritis of the sacro-iliac joint. It is hard to determine from the report which was the primary lesion.

The osteomyelitic process in the ilium may be sufficiently widespread to break through the dome of the acetabulum and produce a secondary suppurative arthritis of the hip joint. This occurred in one instance, while in another the ilium was broken through, and the pus followed the fascial planes of the gluteal muscles and traveled down to the outer side of the thigh.

Symptoms and Physical Signs.—The onset is similar to an acute osteomyelitis in any of the long bones. The temperature may vary from 100° to 104° F., and be preceded by chills. The systemic symptoms vary with the virulence of the infection. Pain cannot be localized very definitely. Patients are apt to point to the buttocks and hip of the affected side, but nearly all complain of pain in either the lower right or left abdominal quadrant, depending on whether the right or left sacro-iliac joint is affected. One patient had persistent vomiting for several days, which was very suggestive of intestinal obstruction. It is the abdominal symptoms that are misleading, and often confusing, in making an early diagnosis. These patients appear very acutely ill. Upon examination some flexion of the hip on the affected side is noted. Flexion of the hip with the knees extended causes severe pain, and is markedly restricted, due to the action of the biceps and semitendinosus muscles which produce motion in the sacro-iliac joint through their pull on the ischium. Extension is restricted, due to the spasm of the iliopsoas muscle. Rotation of the body is extremely painful. This is due to the hinge-like motion on a transverse axis in the sacro-iliac joint, producing an opening and closing movement of the affected joint. Pressure elicits a definite, tender, painful spot directly over the surface projection of the sacro-iliac joint. If the pus has broken through anteriorly, which occurred in all the cases, a definite mass is palpable in the iliac fossa over the lower lateral aspect of the abdomen, as well as by rectal or vaginal examination. There is a fulness in the upper thigh, inguinal region, lateral and posterior aspects of the hip joint, and gross swelling and edema of the entire thigh has been observed. In some instances the swelling has been due entirely to edema, and in others to extravasation of pus in the fascial planes. Edematous swelling always precedes suppuration. It would seem that the edema is due to pressure on the iliac vessels after pus has accumulated in the iliac fossa. Due to the early involvement of the iliopectineal bursa, confusion of this lesion with disease of the hip joint arises. One patient developed a foot drop which persisted until death. This could not be explained except by pressure on the lumbosacral plexus. Later on in

the course of the disease, due either to improper drainage or to the virulence of the infection, the hip joint may become involved, and then the physical signs of suppurative arthritis of the hip joint are present; that is, restriction of all motions, and increased flexion deformity. Depending upon which sacro-iliac is involved, pressure over the lower lateral abdominal quadrants will produce pain on the side of the sacro-iliac joint that is affected.

Diagnosis.—The diagnosis is by no means easy to make, but the keeping in mind of the possibility of this lesion is the first criterion for its more frequent recognition. The initial symptom is pain, gradually increasing in severity, and definitely localized over the sacro-iliac joint. Torsion movements of the trunk provoke excruciating pain, so that considerable reliance should be placed on the difficulty experienced by the patient in turning from side to side even while lying in bed. This is so, particularly before the pus ruptures into the pelvis. This clinical picture, plus such objective signs as a mass in the iliac fossa, palpable either through the abdomen, vagina, or rectum; swelling of the upper thigh, especially under the iliopsoas tendon; fever ranging from 102° to 104° F.; a rapid pulse; a high leukocytosis with a high polymorphonuclear count; and a negative roentgenogram, should render the diagnosis possible. If the patient is not seen until the second or third week, roentgenologic examination will be of definite help, for by that time some destruction is usually demonstrable in either the iliac or sacral portions of the articulation.

Tuberculosis of the lumbar spine complicated by a psoas abscess is easily differentiated. It seems sufficient to mention such differences as the positive roentgenographic evidence of the vertebral lesion, the gradual onset, and the history of the protracted illness in tuberculosis.

It must be also differentiated from appendicitis, as the general symptoms may be the same in both lesions. However, the physical signs are different. In appendicitis, pain is usually localized in the right lower quadrant, but there is no swelling of the upper thigh, and rotation of the trunk does not produce excruciating pain, nor is there pain on pressure over the sacro-iliac joint.

Osteomyelitis of the neck of the femur may simulate sacro-iliac osteomyelitis at the onset, but in the former the physical signs are limited to the hip; they are: restriction of motion in all directions, spasm of all hip muscles, no tenderness over the sacro-iliac joint, and no mass in the iliac fossa. There is a greater degree of hip flexion deformity in osteomyelitis of the femoral neck than in sacro-iliac disease, and rotation of the trunk does not produce pain if the affected hip is steadied firmly during the maneuver. The first case in this series was mistaken for a hip joint lesion.

Prognosis.—The prognosis at best is very poor. It depends essentially on the virulence of the organism; the resistance of the patient; and the adequacy of the drainage. An early diagnosis with proper drainage affords the best outlook. The age of the patient is a factor; the older they are, the less favorable the outcome. If diagnosed and drained very early, the mortality rate

should not be greater than that of pyogenic arthritis of any other joint in the body, but the difficulty lies in the remoteness of the focus from the obvious objective abdominal signs and symptoms. The usual treatment so far has been the drainage of the secondary abscesses, rather than the primary joint lesion. This affects the prognosis unfavorably by increasing the morbidity. Another factor is the ease with which complications may be overlooked, due to the difficulties of making a thorough examination during the early part of the illness. Pain is so acute that movement is almost impossible. In this series, a hip infection was unrecognized in one instance, and in another, a lumbar abscess was undiagnosed, largely because of fixed decubitis and resistance to movement. The lumbar abscess was found at autopsy, accompanied by necrosis of practically all soft tissues up to the first lumbar vertebra on the affected side. If this had been discovered in time, and proper drainage provided, the patient might have survived, although this is questionable as there was a very virulent blood stream infection.

Complications.—The principal complications are the result of abscesses forming in the various locations previously mentioned. In the severe infections the muscles in the path of the pus are completely destroyed, as shown in the postmortem examination of Case 3. The hip joint may be involved, either by extension forward of the osteomyelitic process within the ilium, or through the iliopectineal bursa. Osteomyelitis of the adjacent bones always follows.

Treatment.—As has been mentioned before, drainage of secondary abscesses has been the routine surgical procedure up to the present time, although as long ago as 1889 Gongolpre⁶ described a method of draining the iliac cavity by trephining the pelvis. In 1899 Bardenheuer¹ described the essentially proper approach for radical operations in tuberculous infections of the sacro-iliac joint; Picque¹⁰ in 1909 and Chandler³ in 1933 have done likewise.

The approach used in each instance in this series was similar to that described by Chandler,³ who drained the sacro-iliac joint for pneumococcic infection, although we were not familiar with his method until after operating on the first case. The basic principle in any approach is to provide dependent drainage from behind through the ilium.

The operation consists of an exposure of the posteromedian aspect of the ilium through a skin incision along the posterior half of the iliac crest downward to the posterior inferior spine. The gluteus maximus and medius muscles are then resected subperiosteally, sufficiently lateral to expose that part of the ilium which lies directly over the sacro-iliac joint. The joint is exposed through a large window by the resection of a block of bone from the posterior aspect of the ilium lying over the sacro-iliac joint. That part of the sacrum which goes to form the joint with the ilium is removed. This permits the admission of at least one or two fingers into the pelvis. The iliacus muscle is felt, and lifted from behind. Free pus is usually not found until the pelvic cavity is entered. The wound is packed with vaseline gauze

and left wide open. A plaster of paris spica is applied if the patient's condition permits. If not, a Buck's extension is used until such time as a plaster spica can be applied. The wounds are dressed as infrequently as possible, preferably not for two or three weeks, unless a rise in temperature indicates inadequate drainage, or signs of hemorrhage appear. We have never had to remove the packing because of hemorrhage, not having encountered this complication as yet. If secondary abscesses develop in the thigh or lumbar region which cannot drain through the original incision, these are incised. In



FIG. 1.—(Case 1.) Preoperative roentgenogram showing definite destruction in the lower part of the left sacro-iliac joint.

other words, our postoperative treatment follows the usual principles as advocated by Orr in the treatment of osteomyelitis of the long bones.

These patients are often very ill from dehydration and sepsis, and unable to stand the radical operation at the moment. In such instances it is wise to drain the secondary abscesses in the soft parts, thereby diminishing the amount of toxic absorption, and build up the general condition of the patient by the free use of fluids, intravenously or otherwise, supplemented by blood transfusions. As soon as the general condition has been improved, the radical operation for draining the original focus of infection should be performed.



FIG. 2.—(Case 1.) Postoperative roentgenogram showing operative window through ilium and sacrum at sacro-iliac joint.



FIG. 3.—(Case 1.) Roentgenogram taken 13 months after operation, showing a filling in of the operative defect with apparently a small sequestrum present, which is not causing any trouble.

CASE REPORTS

Case 1.—Mrs. D., aged 24, white, female. Admitted March 9, 1933, to the Gynecologic Service complaining of pain in the lower back. Patient stated that the pain in the back started spontaneously about one week before admission, and that she first noticed it on attempting to turn. It gradually became worse until admission to the hospital. She also gave a history of having fallen on her abdomen five weeks previously, at which time she was two months pregnant. This was followed by a slight bloody discharge, and abortion two weeks later. She had no chills or fever at that time and had no medical attention.

Relevant physical examination on admission was as follows: Temperature on admission was 101° F.; respirations 22. She was pale, well-nourished, well-developed, poor hemic component, first heart sound roughened and had a systolic blow. Abdomen was soft. There was tenderness over the symphysis pubis, and a yellowish discharge from the vagina. There was tenderness over the left sacro-iliac joint. Hips were negative. Blood count on admission showed 9,800 white blood cells; 69 per cent polymorphonuclears; 2,624,000 red blood cells and hemoglobin of 55 per cent. A diagnosis of incomplete abortion and sacro-iliac arthritis was made.

An obstetric consultation on March 11, 1933, showed a soft cervix, large uterus, no masses or tenderness in either fornix. A diagnosis of pregnancy was made. Another gynecologic examination on March 14, 1933, showed the cervix closed, uterus apparently normal and markedly antiflexed. No pelvic masses or tenderness found. This consultation was requested because of the continued high temperature and increasing pain in the back in order to rule out sepsis in pelvic organs.

Roentgenogram March 15, 1933, showed a definite area of destruction in the lower portion of the left sacro-iliac joint.

On March 16, 1933, the patient was transferred to the Orthopedic Service where traction was applied to the leg which gave marked relief of symptoms, although the temperature persisted. On March 28, 1933, she exhibited a marked diffuse swelling over the left hip and thigh in spite of the fact that motions of the hip were free. There was marked tenderness over the left sacro-iliac joint. A provisional diagnosis of sacro-iliac suppuration was made.

Roentgenogram March 29, 1933, showed increased destruction. On the same day the operation as previously described was performed and followed immediately by a blood transfusion. An interesting point observed as the sacro-iliac joint was entered, was the free mobility of the iliac portion of the joint. It was actually a pathologic dislocation of the ilium upward on the sacrum. Free pus was not encountered until the pelvic cavity was entered through the sacrum, the pus having entered the iliac fossa by breaking through the anterior ligament of the joint. The temperature range was between 99° and 105° F. up to April 11, 1933. From then on it gradually declined to normal. Patient was allowed up on wheel chair on June 23, 1933, and she was discharged on July 10, 1933, walking well, wound healed, and wearing a sacro-iliac belt.

Case 2.—Mr. F., aged 20 years, male, white. Admitted to the hospital on March 31, 1933, complaining of pain in the back and general weakness. He stated that three weeks before admission, while working on a truck, he became weak. Had to stop work, went to bed, then felt better and was able to get about until the day before admission, when he complained of severe pain on even slight movement of the legs.

The relevant physical findings on admission: Temperature 104.2° F., pulse 110, respirations 22. A fairly well nourished white male, complaining of pain in the back, and moving with great difficulty. He had severe pain on pressure over the left sacro-iliac joint. There were spasm of the lumbar muscles, and pain on flexion and extension of the thighs. A tentative diagnosis of sacro-iliac infection and sciatica was made at this time.

An attempt was made to apply traction to the left leg to avoid flexion contractures

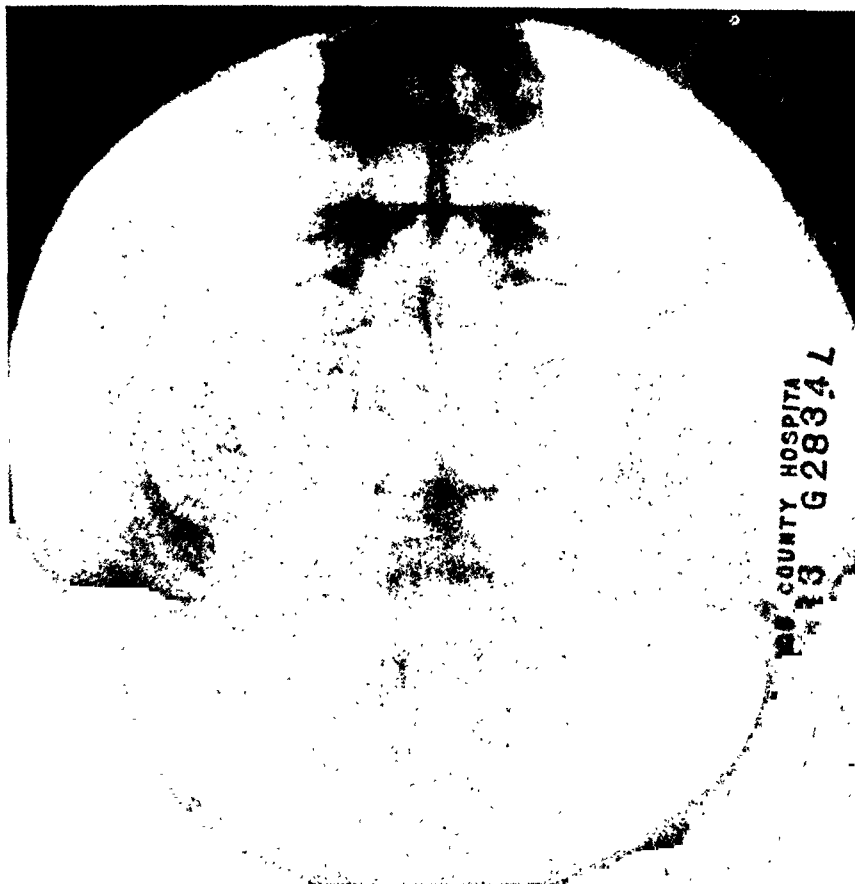


FIG. 4.—(Case 2.) Roentgenogram showing area of destruction about the lower half of the left sacro-iliac joint.



FIG. 5.—(Case 2.) Roentgenogram showing increased density of the ilium and bone proliferation inside of the pelvis over the dome of the acetabulum, and destruction of the hip joint, indicating that the disease extended downward along the ilium and involved the hip joint, producing a secondary suppurative arthritis of the hip joint.

at the hip and knee. This could not be tolerated even though as little as three pounds of weight was applied. It was removed and severe contractures did develop.

During the course of the disease, it was impossible to tell exactly when he developed an infection of the hip joint which drained through the back, as this joint was never directly drained. It healed with bony ankylosis and severe flexion deformity.

Operation was performed April 13, 1933, at which time 8 cc. of pus was evacuated from the soft tissues over the sacrum. Five transfusions were given: April, 19, May 3, 5, 24, and June 9, 1933.

A second operation for radical drainage was performed on May 4, 1933. The left sacro-iliac joint was exposed; on removing the block of bone from the ilium the articular cartilage of the sacrum was found to be eroded. The underlying bone, which appeared gray and necrotic, was easily removed by a curette, but no free pus was encountered. In this instance insufficient bone was removed from the sacrum. The pelvic cavity was not entered. Wound packed with vaseline gauze.

In August 1933, temperature 104° – 105° F., a sinus opened spontaneously over the left lower abdomen. Under anesthesia this was enlarged and found to communicate with the operative wound through the iliac fossa; through and through drains were inserted.

The patient's general condition up to this time had been poor, but after the spontaneous evacuation of the pus in the iliac fossa through the abdominal sinus the temperature began to subside rapidly, and reached normal about October 1. Five months later, March 17, 1934, he was discharged from the hospital walking with a marked limp, the result of a knee and hip flexion contracture. The knee contracture was completely corrected by wedge casts. On April 18, 1934, he was readmitted for the correction of the hip flexion deformity by a subtrochanteric osteotomy of the left femur, and a subperiosteal separation of the hip flexors from the anterior iliac spine. This was successful, and he was discharged July 28, 1934.

In retrospect it is evident that adequate drainage of the iliac fossa was never established until spontaneous evacuation through the abdominal sinus, five months after the inception of the disease. Had proper drainage been provided, ankylosis of the hip would probably have been prevented, and his convalescence materially shortened.

Laboratory Findings.—Blood cultures were negative. Smear of the pus showed gram positive cocci in short chains, and culture, streptococcus brevis. Microscopic examination of bone removed from the sacro-iliac joint showed marked infiltration of bone marrow spaces by monocytic cells, and occasional areas of necrosis of bone spicules.

Roentgenologic Findings.—Five days after admission, April 5, 1933, there was a shadow in the lower part of the left sacro-iliac joint, suspicious of osteitis. Thirteen days later, and five days after the first incision and drainage, an increased area of destruction was reported. On April 27, 1933, nine days later, and one week before radical drainage, a third roentgenogram demonstrated still greater destruction of the joint.

Six months after operation, January 26, 1934, there was no evidence of active bone pathology in the sacro-iliac joint. The lesion had healed. There was a definite subperiosteal deposit of bone along the inner surface of the ilium within the pelvis, from the sacro-iliac joint to the ischial spine just anterior to the acetabulum, indicative of invasion of the hip joint via this route.

Case 3.—Miss A. Q., aged 19, white female. Admitted to the hospital January 26, 1934, complaining of pain in the right thigh. About four weeks before admission she had had a "cold." About five days after this, before the "cold" had cleared up, she noticed that on moving the right leg she had a dull pain in the thigh. For two weeks, despite progressively increasing pain, she continued to work, when she slipped and fell with both lower extremities abducted. She was carried home, and the pain became severe, and the leg stiff. Although no other joints were affected, the condition was diagnosed as rheumatic fever, and the patient treated at home for a week.

On admission the temperature was 102° F., pulse 112, and respirations 24. The patient was a well-developed girl, appearing acutely ill, moderately anemic, and evidently in pain. There was a systolic blow at the apex, which was not transmitted to the axilla. The abdomen was tense, although there was no definite rigidity. Some tenderness of both right and left lower abdominal quadrants was elicited. No masses were palpable. There was swelling and tenderness of the upper half of the right thigh, without local redness of the skin. No areas of fluctuation were present. The leg was held in 75° of flexion; all movements of the knee were limited, and any motion of the hip joint greatly aggravated the pain. Tenderness on pressure over the right shoulder joint was noted, and dull pain occurred on movement. A provisional diagnosis of acute infectious arthritis of the right hip, with a mild secondary anemia and mitral disease was made.

Traction was applied, ameliorating the pain. The swelling in the upper thigh persisted. An attempt was made to aspirate the joint, but no fluid was obtained. Four



FIG. 6.—(Case 3.) Roentgenogram showing operative window through the sacro-iliac joint, and early destruction of the hip joint. This hip joint became infected through the iliopectineal bursa.

days after admission the temperature had risen to 104.2° F., the right shoulder pain persisted, pain in the hip was localized over the great trochanter. A medical consultation resulted in an opinion that the condition was not rheumatic fever. A gynecologic survey suggested the possibility of salpingitis.

Two days later, February 2, 1934, rectal examination revealed definite tenderness over the right sacro-iliac joint, but no evidence of a mass in the iliac fossa. On February 6, swelling of the upper thigh had increased, the right sacro-iliac was very tender to palpation, and roentgenograms showed a suspicious area of osteitis in the lower angle of the joint. Arthrotomy was performed two days later. Within the cancellous portion of the ilium, about one-half inch beneath the outer table, a few drops of pus were encountered; culture showed a staphylococcus aureus. Penetration was continued through the ilium into the sacro-iliac joint, and thence through the sacrum into the pelvis. The wound was packed with vaseline gauze.

The immediate postoperative reaction was stormy. The fever subsided somewhat, but continued to spike to 102° or 103° F. On February 23, 15 days postoperative, the patient began to vomit. No signs of intestinal obstruction were elicited. The attack subsided. On March 15 pain in the right leg, which had been dull and intermittent, increased in severity and constancy. On aspiration of the hip joint a turbid, light yellow fluid was obtained, which on culture showed staphylococcus aureus. Roentgenograms disclosed some diminution of the joint space and roughening of the articular surfaces. Drainage of the hip through an anterior incision was instituted.

In May 1934 a massive soft tissue abscess, which had gradually formed on the lateral surface of the thigh, was drained. The patient was extremely septic, pulse rapid, and the temperature, which had been ranging from 102° to 103° F., began to subside. Her general condition rapidly became weaker, and death occurred on May 26, 1934.

Throughout the illness repeated transfusions were given. Glucose and salt solutions were administered by infusion and clysis. Iron and liver therapy was used in conjunction with the transfusions to combat the severe secondary anemia.

Laboratory Findings.—Two blood cultures were taken but were contaminated. Blood Wassermann was negative. Gonococcic fixation test was negative. Specimens of the removed bone, on section, showed acute osteomyelitis.

Postmortem Examination.—On stripping the psoas muscle a large abscess extending from the brim of the pelvis upward to the level of the first lumbar vertebra on the right side of the abdomen was found. The muscles and fatty tissue had all undergone necrosis. The anterior surface of the sacrum was roughened and studded with necrotic areas. The head of the right femur was similarly involved. Diagnosis: Chronic osteomyelitis of the sacrum, right ilium and right femur.

COMMENT.—The right lumbar abscess was never diagnosed. It is doubtful whether drainage of this abscess would have altered the course of the disease, in as much as the essential picture was that of overwhelming infection.

Case 4.—Mr. S., aged 5 years, white, male. Admitted to the General Surgical Service March 16, 1932, complaining of pain in the abdomen of two days' duration, and pain in the right hip for one week. Temperature 101.8° F., pulse 128, respirations 28. Twelve days prior he had been knocked down by a bicycle. The following day a swelling in the right gluteal region was noted, and some pain complained of, which disappeared after using a liniment. Six days later a limp developed, pain in the right buttock returned, and abdominal pain began on the tenth day.

On admission the patient was toxic, moderately dehydrated, mucous membranes dry, tongue coated and both legs were flexed on the abdomen. Attempts to extend the thighs provoked pain, but hip motions within a restricted range were free and painless. There was generalized abdominal tenderness, with maximum intensity in the right lower quadrant, and rebound tenderness referred to McBurney's point. Three days after admission a swelling and induration on the medial aspect of the right thigh appeared. Operation was performed to institute drainage, but no pus was obtained. Six days later, on aspiration in the gluteal region, thick pus was obtained. Culture showed a growth of staphylococcus aureus.

On the following day, March 24, the area was incised, and the hip joint exposed. No infection observed. A pus pocket was found and evacuated posteriorly in the region of the right sacro-iliac joint. Penrose drains were inserted. There was some remission of the temperature for a week, but then a rapid rise occurred, spiking from 104° to 107° F. Blood culture at that time was negative. The fever persisted for many weeks, subsiding by lysis during July. He was discharged in October 1932, seven months after admission.

Eighteen months later, March 29, 1934, the patient was readmitted complaining of right lower quadrant pain of two days' duration, associated with vomiting. Both hips

were flexed on the abdomen. There were muscular rigidity and right lower quadrant tenderness. A diagnosis of acute appendicitis was made. On consultation with the General Surgical department the author disagreed with the diagnosis, and advised drainage of the sacro-iliac for osteomyelitis of the iliac bone. This was done by an associate, who did not carry the penetration through the entire pelvic wall. The abdomen was opened at the same time. Findings.—No free fluid, appendix normal, a retroperitoneal mass in the right iliac fossa. Two days after operation pus drained from the sacro-iliac wound. Convalescence was complicated by varicella, for which transfer to a contagious disease hospital was necessary. On return, May 9, 1934, septic temperature continued. The hip joint was opened on May 17. No infection was



FIG. 7.—(Case 4.) Roentgenogram showing complete fusion of the sacro-iliac joint and involvement of the entire ilium. This patient was never adequately drained. We saw him during an acute exacerbation after the primary lesion had been healed and the patient had been walking about.

found within the joint, but a pocket was located beneath the lesser trochanter on the femoral shaft, evidently an extension along the iliopsoas muscle from the iliac fossa. The temperature subsided in seven days, and he was discharged two months later, July 15, 1934.

COMMENT.—On the first admission the diagnosis was entirely missed, and definitely overlooked on his second admission, resulting in a laparotomy with negative findings. Roentgenograms demonstrated involvement of the entire ilium and part of the sacrum. The pelvis was never adequately drained until

the secondary abscess areas, especially that along the iliopsoas tendon, were evacuated.

Case 5.—Mrs. P., aged 46, colored, female. Admitted to the hospital November 19, 1934, because of pain in the region of the right hip. Onset was acute. Three weeks before admission she had chills and fever, followed by pain in the right hip region, which gradually became worse until it was so severe that she was confined to bed. Pain was aggravated by motion, and relieved by rest. It radiated down the thigh to the knee and ankle. No history of injury. Temperature on admission was 100° F., pulse 112, respirations 26.

Relevant physical examination showed a middle-aged emaciated Negress, apparently chronically ill; unable to sit or stand. Some crepitating râles at the base of the lungs. There was a definite fulness about the right hip joint with tenderness in the inguinal region just below Poupart's ligament. Flexion of the hip was fair; rotation somewhat painful. Tenderness was elicited on pressure over the right sacro-iliac joint. The hip was maintained in about 10° flexion. The patient appeared very ill.

An orthopedic survey was made November 27, 1934. At that time there were two masses in the lower right abdomen; the one toward the midline was rather firm and movable, and not tender; a typical fibroid tumor in the uterus. The other mass filled the entire right iliac fossa on the right side. The groin showed a distinct fulness below Poupart's ligament. Vaginal examination revealed a fulness in the right iliac fossa, and a downward displacement of the uterus. There was also a distinct mass behind the hip joint, in the lower gluteal region. Tenderness was present on pressure over the sacro-iliac joint. Roentgenograms were negative for bone pathology. No pus was obtained from aspirating the mass in the iliac fossa, but was obtained from the swelling behind the hip joint.

A diagnosis of sacro-iliac disease was made, but radical drainage was delayed on account of the poor general condition of the patient. The gluteal abscess was drained December 3, 1934. Death occurred ten days later, and no autopsy could be obtained.

Laboratory Findings.—Blood Wassermann was negative. Culture of pus from the hip joint showed a nonhemolytic streptococcus. Smear showed many gram positive cocci in short chains.

CONCLUSIONS

- (1) Five cases with suppuration of the sacro-iliac joint are reported.
- (2) The difficulty in making an early diagnosis has been pointed out.
- (3) A plea is made for earlier diagnosis and proper adequate drainage in these cases.
- (4) The group reported had a mortality of 40 per cent.

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SERUM PHOSPHATASE IN FRACTURE REPAIR

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A STUDY of a series of major fractures has been conducted to determine the possible clinical significance and the relationship between the healing of fractures and the activity of the enzyme phosphatase of the serum. The importance of the enzyme phosphatase in phosphorus and bone metabolism has been clearly demonstrated in recent years. Early studies by Robison¹ showed that the enzyme was capable of hydrolyzing phosphoric esters such as glycerophosphates and hexosephosphates into inorganic phosphates. Robison and Soames² demonstrated that bone, and especially growing bone, contained a high concentration of the enzyme and concluded that a relationship existed between the enzyme and bone metabolism. Their hypothesis was as follows: "Osteoblasts and hypertrophic cartilage cells and certain cells of the inner border of the periosteum in a growing bone contain or can secrete a very active phosphatase which, by hydrolyzing the salts of phosphoric esters brought to the ossifying zone by the blood stream, cause a local increase in the concentration of phosphate ions. The solubility product for calcium phosphate, which is probably very nearly reached at the concentration of inorganic phosphate and ionized calcium normally present in the circulating plasma at normal plasma Ph, is thus exceeded locally and a deposition of the calcium phosphate is brought about in the neighborhood of the cells which secrete the active enzyme."

It is to be expected therefore that with the formation of callus in the process of fracture repair, a local increase in the phosphatase activity will be found. Regen and Wilkins,³ Botterell and King,⁴ in experimental work on animals have shown that the phosphatase activity of bone at the site of fracture was greatly increased as compared with that of bone from other sites in the same animal. They found that the increase may be as much as ten to twenty times normal and reached its maximum about three weeks following fracture. The phosphatase activity of the bone the day following fracture showed no change from the normal and no appreciable increase was noted until about the fourth day following fracture.

Increase in serum phosphatase activity has been reported in many pathologic bone conditions, notably Paget's disease, osteogenic sarcoma and *osteitis fibrosa cystica*. It has also been repeatedly demonstrated that the phosphatase activity of the involved bone in these conditions is extremely high. Franseen and McLean⁵ have recently shown that in cases of osteogenic sarcoma the level of the serum phosphatase can be used as an index of the activity of the tumor. They found that with surgical removal of the tumor mass the plasma

phosphatase fell rapidly to normal and became elevated again with the recurrence of the tumor.

It has been noted by Kay⁶ and Bodansky and Jaffe⁷ that during the process of fracture repair there was an elevation of the serum phosphatase activity. Hunsberger and Ferguson⁸ carried out serial determinations of serum phosphatase activity during repair of fractures in 18 clinical subjects and found that at varying intervals after fracture there was an increase in the serum phosphatase activity, with a slow return to normal as union progressed. They suggested that the extent of bone damage might account for the lack of uniform response in all cases.

According to various investigators the mechanism for the increase in serum phosphatase levels following fractures is not clear. Kay⁹ has suggested that the enzyme is liberated from the damaged bone and soft tissues. He also suggests that the increased level may represent an overflow following increased activity locally at the fracture site. McKeown, Lindsay, Harvey and Howes¹⁰ believe that the increase is due to mobilization of phosphatase from other depots such as the kidney, liver, *etc.*, in response to a substance elaborated by the fracture.

It was thought that a study of serial serum phosphatase determinations in a large series of fractures might determine:

1. If there was a consistent rise in serum phosphatase activity following fractures.
2. If the rise was not consistent, was there any correlation between the level of serum phosphatase and (a) the location of the fracture, and (b) the extent of the injury.
3. If the serum enzyme level could be used as an index of the rate of healing of the fracture and as a prognostic sign in the development of delayed or nonunion.
4. The mechanism for the increase in the serum phosphatase activity following fractures.

A series of 75 cases of fractures in adults has been studied. These cases were unselected with the exception that the majority of them were major fractures requiring hospitalization for a considerable period of time. Serial determinations of serum phosphorus and phosphatase were made the day following fracture and thereafter at weekly intervals for the following three weeks. In a few cases the studies were followed until union was complete. With the knowledge that diet, especially a high carbohydrate diet, could produce variation in the serum phosphatase level it was thought advisable to keep these patients on a standard diet. However, it was found to be very difficult to keep this number of patients on a weighed diet over the length of time necessary, and accordingly a uniform diet was planned and given to all fracture cases under study.

The Bodansky method of phosphatase determination has been used throughout in this series. According to Bodansky, the average normal adult serum phosphatase reading is 2.6 units with levels ranging from 1.5 to 4. In

serial determinations on normal individuals taken at weekly intervals, an average fluctuation of about one unit has been found. Accordingly, in computing whether there has been an increase or decrease in the serial determinations in this series, allowance has been made for this error.

The level of the serum phosphatase, of course, was not known prior to the fracture in any individual case. However, in about one-fourth of the cases, determinations have been made after complete healing of the fracture and the figures corresponded very closely with the readings taken the day following fracture. It is assumed therefore that the original reading probably represents the normal level of serum phosphatase for that individual.

A study of the serum phosphatase levels failed to reveal any consistent increase and, with very few exceptions, any significant change during the four weeks following fracture. In a few of the cases there was a striking increase in the serum phosphatase level but the majority showed only a very slight increase and many showed no change. At the end of one week 29 per cent of the readings were higher than the original levels, 16 per cent were lower and 55 per cent remained unchanged. At two weeks 43 per cent were found to be higher, 22 per cent lower and 35 per cent unchanged from the original levels. At three weeks 51 per cent were higher, 12 per cent lower and 37 per cent unchanged. However, on analyzing the individual cases, we find no consistent rise in the phosphatase level from week to week. Many of the cases showed a decreased value in the first and second weeks with perhaps a slight rise in the third week. Others showed a rise at the end of the first week with a subsequent drop to normal in the second and third weeks. Only 14 of the 75 cases showed a continued rise each week. With the exception of the cases of Paget's disease, the average phosphatase readings for the series were: on admission 3.74 units; seventh day 4.43 units; fourteenth day 4.69 units; and twenty-first day 4.77 units (Chart I).

An attempt was then made to correlate the serum phosphatase levels with the site of fracture. It had been suggested by Kay⁶ that the cause of frequent

TABLE I
FRACTURES OF TIBIA (JUNCTION OF LOWER AND MIDDLE THIRD)
Serum Phosphorus and Phosphatase Determinations

Case	Admission		7th Day		14th Day		21st Day	
	Phos.	Phospha- tase	Phos.	Phospha- tase	Phos.	Phospha- tase	Phos.	Phospha- tase
17	2.20	4.87	3.77	2.34	2.68	4.25	3.20	6.60
25	3.50	4.92	4.20	9.13	3.88	7.16	3.92	5.64
27	2.70	4.78	3.48	5.32	3.68	5.44	3.70	5.98
29	3.50	4.34	3.62	7.02	3.20	7.31	3.48	4.70
30	2.06	5.39	3.05	4.29	3.66	4.56	2.88	6.22
31	4.58	5.00	4.30	8.02	4.10	6.30	3.84	5.48
37	4.39	6.96	4.83	4.28	3.82	3.17	4.16	4.36
40	3.28	3.32	3.47	3.15	3.16	2.86	3.98	4.78
Average	3.27	4.92	3.84	5.44	3.52	5.13	3.64	5.47

PHOSPHATASE IN FRACTURE REPAIR

delayed or nonunion of fractures, occurring in certain locations such as the lower third of the tibia and the neck of the femur, might be due to the fact that these areas are low in phosphatase. If this were true, we might also expect lower serum phosphatase levels following fracture in these locations. In this series there were eight fractures at the junction of the lower and middle third of the tibia and ten intracapsular fractures of the femur (Tables I and II). However, as can be seen in Chart I, the phosphatase curves for these fractures closely approximated the curve for the total series.

TABLE II

INTRACAPSULAR FRACTURES OF THE FEMORAL NECK *Serum Phosphorus and Phosphatase Determinations*

Case	Admission		7th Day		14th Day		21st Day	
	Phos.	Phospha- tase	Phos.	Phospha- tase	Phos.	Phospha- tase	Phos.	Phospha- tase
5	3.80	2.24	3.56	3.06	3.80	3.94	4.58	4.47
6	4.20	3.54	3.60	2.98	3.65	4.41	3.75	4.32
22	3.07	7.01	3.22	7.85	3.28	7.98	3.15	6.98
26	3.64	6.53	4.24	5.48	3.30	9.02	3.68	7.64
45	2.96	2.96	3.00	3.25	3.64	3.36	3.78	3.34
54	2.78	4.43	3.14	2.80	3.76	2.79	2.84	2.17
56	2.76	2.08	3.30	4.14	3.24	3.82	3.70	2.79
64	3.36	1.92	4.00	3.06	4.22	2.68	3.56	3.12
65	3.36	2.18	4.01	2.59	4.01	2.22	4.22	3.88
72	2.38	1.58	3.48	3.78	3.50	3.98	4.06	4.65
Average	3.23	3.45	3.55	3.90	3.64	4.42	3.73	4.33

TABLE III

FRACTURES WITH DELAYED AND NONUNION *Serum Phosphorus and Phosphatase Determinations*

Case	Bone Involved	Admission		7th Day		14th Day		21st Day	
		Phos.	Phos- pha- tase	Phos.	Phos- pha- tase	Phos.	Phos- pha- tase	Phos.	Phos- pha- tase
4	Femur (Shaft)	2.90	3.48	2.90	6.56	3.46	7.09	3.44	3.94
16	Femur (Shaft)	4.14	2.64	4.14	2.15	3.68	3.45	3.78	5.28
21	Femur (Shaft)	3.26	2.17	4.22	9.33	4.07	3.67	3.85	3.80
25	Tibia	3.50	3.68	4.20	9.13	3.88	7.16	3.92	5.64
31	Tibia	4.58	5.00	4.30	8.02	4.10	6.30	4.22	6.79
50	Femur (Neck)	2.70	2.22	3.70	3.69	4.11	3.23	3.56	2.38
58	Femur (Neck)	3.38	1.76	3.78	2.29	3.54	3.36	4.06	3.80
Average		3.49	2.99	3.89	5.88	3.83	4.89	3.83	4.52

There were seven cases of delayed and nonunion (Table III). It can be seen by the accompanying diagram (Chart I) that, with the exception of an increase in the phosphatase activity at the end of the first week, there was no

characteristic change in the levels to distinguish these cases from those that went on to union in the normal time.

It would seem to follow that if the increase in serum phosphatase following fractures were due to either an overproduction of the enzyme at the site of fracture or to a generalized response from other depots, then with multiple fractures and those following severe trauma with comminution of the fragments one would expect a marked increase in the serum enzyme level. However, an analysis of five such cases shows no abnormal increase and in fact in some instances there was found to be a decrease (Table IV).

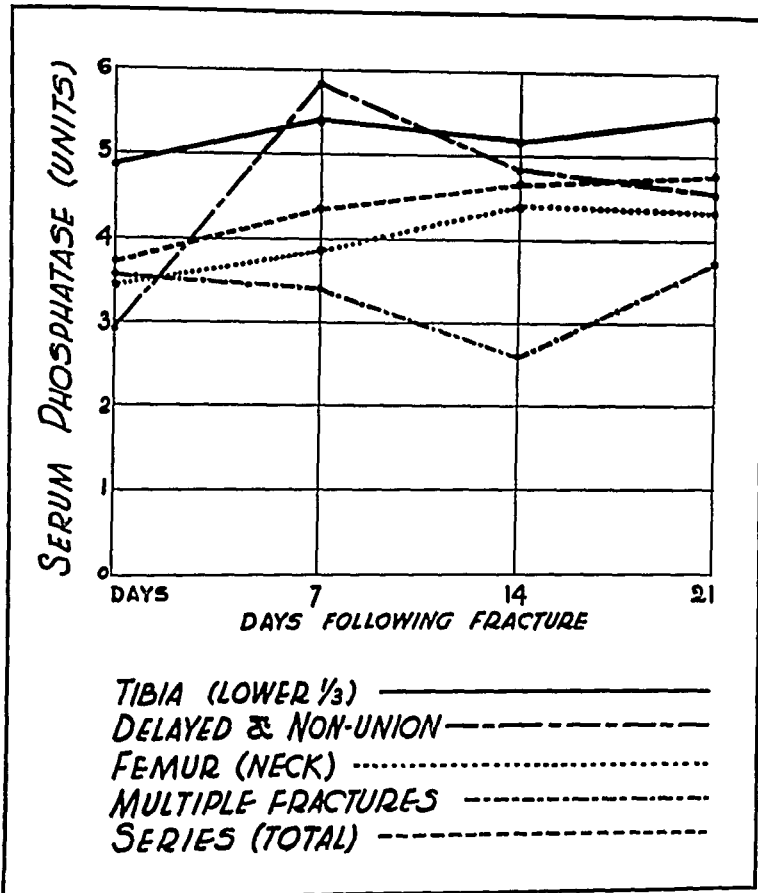


CHART 1.—Showing composite amount of serum phosphatase recovered in the various types of fracture considered.

Two cases of Paget's disease with fractures were studied. These were both pathologic fractures of the humerus with very little displacement of the fragments. The serum phosphatase readings are shown in Table V. Union took place in the normal length of time without an abnormal amount of callus formation. It would appear from a study of the first case (O.W.) that a marked increase in the serum phosphatase activity had taken place following fracture with a subsequent return to the original level in the third week. However, the second case (J.B.) showed very little fluctuation.

It has been reported by Tisdall and Harris¹¹ that an increased blood phosphorus reading was found consistently during the course of normal heal-

PHOSPHATASE IN FRACTURE REPAIR

TABLE IV

MULTIPLE FRACTURES

Serum Phosphorus and Phosphatase Determinations

Case	Bones Involved	Admission		7th Day		14th Day		21st Day	
		Phos.	Phos-pha-tase	Phos.	Phos-pha-tase	Phos.	Phos-pha-tase	Phos.	Phos-pha-tase
39	{Humerus, Ribs, Olecranon, Pelvis	4.92	4.93	4.20	2.60	3.96	1.66	4.06	3.99
45	{Tibia Femur (Neck)	2.96	2.96	3.00	3.25	3.69	3.36	3.78	3.34
60	Femur, Pelvis	2.20	2.62	2.80	2.88	3.60	2.88	4.04	3.08
69	{Pelvis Clavicle}	4.60	2.94	4.26	3.22	3.34	2.11	5.02	2.98
71	{Pelvis Clavicle}	4.34	4.26	5.02	4.07	3.50	2.88	5.16	5.12
Average		3.80	3.54	3.85	3.40	3.62	2.57	4.41	3.70

ing of fractures. The absence of such a rise was presumptive evidence of a threatened nonunion. This was later refuted by Eddy and Heft,¹² Murray¹³ and others, who found no consistent rise in the blood phosphorus following fractures. Hunsberger and Ferguson⁸ reported an inverse ratio between the curves of serum phosphorus and phosphatase during the repair of fractures. A study of the present series appears to substantiate the findings of Murray

TABLE V

PAGET'S DISEASE WITH PATHOLOGIC FRACTURES

Serum Phosphorus and Phosphatase Determinations

Case	Bone Involved	Admission		7th Day		14th Day		21st Day	
		Phos.	Phos-pha-tase	Phos.	Phos-pha-tase	Phos.	Phos-pha-tase	Phos.	Phos-pha-tase
O. W. 32	Humerus	3.41	27.60	3.12	37.00	3.92	34.20	3.46	24.70
J. B. 35	Humerus	3.26	19.10	3.82	15.84	4.28	22.72	3.76	18.74

in that very little fluctuation in the blood phosphorus level was noted. No decrease in blood phosphorus was noted in the cases of delayed and nonunion studied (Table III). Also, no evidence of an inverse ratio between the curves of phosphorus and phosphatase was found (Tables II, III, IV and V).

DISCUSSION.—It seems evident from the foregoing, therefore, that following many fractures there is a slight rise in the level of the serum phosphatase activity. This is not a consistent finding, however, and an attempt to analyze the various types of fractures has failed to account for the cause of this inconsistency. Undoubtedly phosphatase plays an important part in the process of fracture repair, as evinced by experimental work showing a marked

increase in its activity locally following fractures. It may be that in some cases there is a greater local phosphatase activity than in others, resulting in an overflow into the blood stream. It is doubtful that there is a generalized response from other organs high in phosphatase, as in this case one would expect an earlier and more consistent rise of the serum level. It would appear that the increase in serum phosphatase following fractures is analagous to the increase seen in some cases of osteogenic sarcoma. In the latter instance the increased serum phosphatase activity is presumably dependent upon activity of the bone tumor. Similarly, it may be assumed that the increase in phosphatase activity at the fracture site as demonstrated by Regen and Wilkins, Botterell and King, results in a secondary increase in the serum level.

No conclusion can be drawn from the two cases of Paget's disease studied, with the exception perhaps that a high level of serum phosphatase activity does not accelerate the rate of healing of fractures. In the literature reviewed, no observers have reported accelerated healing of fractures in cases of Paget's disease or osteitis fibrosa cystica.

CONCLUSIONS

(1) There is not a consistent rise in the serum phosphatase level in the course of fracture healing although in many cases there is a slight increase, while in a smaller group there is a decrease.

(2) The increased serum phosphatase activity following fractures appears to be secondary to the increased activity at the fracture site and not vice versa.

(3) The serum phosphatase level following fracture is not an index of the healing or rate of healing of the fracture.

(4) No significant change in the blood phosphorus level following fracture was noted.

The author is indebted to Doctors F. W. Hartman and Victor Schelling of the Department of Pathology, Henry Ford Hospital, for their cooperation in the preparation of this paper.

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BRIEF COMMUNICATIONS AND CASE REPORTS

RECURRENT DUODENAL ULCER FOLLOWING PREVIOUS PERFORATION *

PARTIAL GASTRECTOMY

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CASE REPORT

A MALE, aged 42, was admitted to Beekman Street Hospital October 27, 1933, shortly after a sudden collapse resulting from an attack of severe upper abdominal pain. For three days he had been suffering from epigastric discomfort which had grown progressively more severe, culminating in the above episode. In 1929, after a 15 year history of recurrent postprandial pain, he had a perforation of a duodenal ulcer which was sutured at Kings County Hospital. He remained well for about one year, following which there was a recurrence of digestive complaints which persisted until the time of admission.

Examination suggested either a walled-off perforation or a subacute perforating duodenal ulcer. The acute signs subsided after 48 hours, but the digestive discomfort persisted despite medication and Sippy diet. Roentgenograms revealed a constant defect on the lesser curvature of a deformed bulb suggesting a penetration from it. Because of the history and the uncontrollable symptoms, the patient was explored November 11, 1933. The under surface of the liver was found to be intimately adherent to the first portion of the duodenum, which, when separated, revealed an open penetration extending into the gastrohepatic ligament, arising from the anterior aspect of an adherent duodenal ulcer of the posterior wall. A partial gastrectomy, including the ulcer, was performed, employing the Hoffmeister modification to effect a posterior no-loop suture gastro-jejunostomy.

After an uneventful postoperative course, the patient was discharged on the seventeenth day. Except for mild epigastric discomfort, particularly after large meals, during the first six months, he has remained well and free from digestive symptoms.

The impression that most cases of acute perforated duodenal or pyloric ulcer tend to remain well is controverted by careful follow up observations which reveal a 40 to 50 per cent recurrence of symptoms in such cases. The explanation for this is revealed in resected material obtained by partial gastrectomy. A survey of 25 such cases, 22 from Mt. Sinai Hospital and three from Beekman Street Hospital, showed the presence, in every instance, of either a separate duodenal ulcer of the posterior wall or an encircling ulcer of the posterior wall, tending to perforate at its most anterior aspect, as exemplified in the case presented. These lesions, unquestionably present at the time of the acute perforation, persist and are responsible for recurrent symptoms. It is obvious why anatomically anterior ulcers are the ones to

* Presented before the New York Surgical Society, October 9, 1935.

perforate into the free peritoneal cavity, and posterior ulcers tend to be walled off by either the pancreatic capsule or the liver. Apparently it is the solitary ulcer of the anterior wall which tends to remain well after an acute perforation.

The practical significance of these observations may be applied to the management of these lesions. The simple suture is favored for an acute perforation as the safest procedure in an immediate, grave surgical condition. When uncontrollable recurrent symptoms manifest themselves, surgery is indicated, partial gastrectomy being favored, whenever feasible, as the procedure most likely to give the best result.

DISCUSSION.—DR. RICHARD LEWISOHN (New York) stated that these ulcers should be called persistent rather than recurrent ulcers. At Mt. Sinai Hospital 39 per cent of the patients had persistent symptoms after an acute perforation of a duodenal ulcer, due either to the fact that an ulcer of the anterior wall persists in spite of the suture or that, in addition to the anterior ulcer which perforated acutely and was sewed over, an ulcer of the posterior wall existed which, of course, was not affected by the surgical procedure. The procedure now favored at Mt. Sinai Hospital is simple suture of the ulcer without a gastro-enterostomy, on account of the dangers of a subsequent gastrojejunal ulceration. Enderlen has reported 51 per cent of gastrojejunal ulcers following gastro-enterostomy in connection with an acute perforation. Of course, large punched out ulcers may be encountered where a safe suture is practically impossible. If this type of lesion comes to the operating table early, that is within six hours after the perforation, the surgeon should weigh the evidence, whether it is not safer for the patient to have a primary partial gastrectomy performed rather than an unsafe suture of the perforation with the possibility of a postoperative leak.

DR. HENRY F. GRAHAM (Brooklyn) called attention to an article by Doctor Platou some years ago which contained an analysis of 70 cases of operation for perforation of duodenal ulcer with end-results. He found that when simple suture was performed, one-third came to later operation, one-third had persistence of symptoms, and one-third were cured. In one case of a large blow-out ulcer nothing was done other than to pack the perforation with gauze. A complete recovery without recurrence of symptoms ensued. The cases of suture plus gastro-enterostomy were all free from symptoms of disease. Doctor Graham stated that he had had two or three patients in whom a simple suture for perforation was followed by death. Nevertheless, after several years' experience with it, he felt it to be the method of preference. At the Methodist Hospital the rule is that if the patient's general condition is good and he is seen early enough after the acute perforation of a duodenal ulcer, gastro-enterostomy is performed; otherwise, simple suture.

DR. FRANK E. BERRY (New York) said that in early cases where there is an extremely large perforation presenting a difficult problem for simple repair, primary resection must be seriously considered. Such a case reported before the New York Surgical Society some years ago is still well although eight years have elapsed since perforation.

DR. JOHN A. MCCREERY (New York) added that the case of acute perforation in which a resection was done by Doctor Berry represented the

only one in 150 acute perforations on his service in which this operation had been possible. In a few others it would have been advisable, but they were late cases in which the patient's condition made such a procedure unwise. In the average case, the proper procedure was simple closure of the perforation. Ten years ago it was Doctor McCreery's belief that he could tell, at the time of perforation, whether any additional procedure, such as gastro-enterostomy, would be necessary. At present, however, it is his conviction that the course of ulcer following perforation cannot be determined, and, therefore, closure alone is indicated. He could not entirely agree that patients returning for further treatment have persistent rather than recurrent ulcers. He has had patients who had been free from symptoms for as long as 11 years following perforation, only to return with definite ulcer symptoms, often requiring operation. The period of freedom from symptoms in these cases was so long that it seems more probable that the second ulcer was a new rather than a persistent one, even though occurring at the same site as the original lesion. The procedure in secondary operations should be governed by the same principles that decide the procedure at the primary operation. In many of his secondary operations for obstruction, he has been satisfied with a posterior gastro-enterostomy.

STRANGULATED UMBILICAL HERNIA AND CONCOMITANT GANGRENOUS APPENDICITIS *

CONDICT W. CUTLER, JR., M.D.

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Case Report.—A female, aged 29 entered Roosevelt Hospital May 22, 1935, complaining of having had abdominal pain for four days, accompanied by vomiting and complete obstipation for two days. Since the birth of a child five years before, she had had a swelling in the region of the navel. This mass, always present, was larger at certain times. Occasionally, after exertion, it became quite hard, swollen and painful, with occasional associated abdominal cramps.

Four days before admission, after lifting a heavy weight, the mass became larger and painful, and was accompanied by general abdominal pain of cramplike character. She felt sick and feverish and a laxative did not relieve her. For the two days immediately before admission, there was continual severe general abdominal pain, frequent emesis, and inability to pass flatus.

On examination she appeared prostrated and dehydrated. The abdomen was distended, tympanitic, somewhat rigid and generally tender. At the umbilicus, and extending toward the right, was a protruding mass. There was some superficial redness over the mass, which was firm, not tympanitic and tender. The patient said it was twice its usual size. There was also marked tenderness in the right lower quadrant. Temperature, 101.2° F. Leukocytes, 21,000; polymorphonuclears, 92 per cent. The high leukocytosis, in conjunction with the relatively low temperature and the local tenderness in the right lower quadrant, led to the suspicion of acute appendicitis. Yet the evidence of strangulated, or at least incarcerated, umbilical hernia, with obstructive symptoms, could not be ignored.

Operation.—After an infusion, a right rectus incision was made. Through this the hernial sac was first investigated. Its wall was markedly thickened and edematous, and it contained a mass of inflamed, adherent and strangulated omentum, but no intestine. The omental mass was resected, and its stump reduced. Exploration of the right

* Presented before the New York Surgical Society, October 23, 1935.

lower quadrant was now done. Here a partially walled off abscess which surrounded an appendix was encountered, lying in the flare of the ileum, covered with fibrin and pus, gangrenous in its distal third and perforated near the tip. This was removed and a stab wound was made in the right inguinal region for drainage. With little hope of success, in a field already contaminated, an improvised repair of the hernial orifice was effected, the sac having been removed. This wound was also drained.

The patient's recovery was complicated by a bronchopneumonia. The temperature reached normal on the thirteenth day. The rectus wound did not break down, but a sinus tract persisted in the drained area near the umbilicus. The stab wound closed and she was discharged on the twenty-first postoperative day. Two months later she was readmitted for the drainage of a large mural abscess which had developed in the right abdominal wall. Her recovery was uneventful and the hernia has not recurred as yet.

The case is shown as illustrating the confusing concomitance of two acute surgical conditions within the abdomen.

DISCUSSION.—DR. ELLSWORTH ELIOT, JR. (New York) said that associated conditions of the abdomen—they might better be called coexisting—could be divided into two groups: the first consisting of those in which the two lesions are rather intimately related to one another, and the other consisting of those in which two or more lesions are entirely independent of one another. If the gangrenous appendix had been within the hernial sac, it would have been a coexisting lesion intimately associated with the hernia. However, it was entirely separate from the sac and hence the lesions would belong to the group of independent coexisting conditions. An interesting instance belonging to the group in which the lesions were interdependent was one reported by Dr. E. R. Easton, occurring at the Knickerbocker Hospital, of a gangrenous appendix within the hernial sac, in an adult male who, after sudden exertion, experienced a pain in the region of the umbilicus, followed shortly by the appearance of a hernia in the right inguinal region which became irreducible. A diagnosis of an acute appendix in addition to the hernia was made, being influenced chiefly by the fact that the abdominal symptoms were referred to McBurney's point above and to the outer side of the internal abdominal ring. It is important in cases of coexisting lesions to determine and weigh the difference in the physical signs other than those of hernia alone. Had strangulated hernia been the only lesion, certainly before peritonitis developed the symptoms would have been localized to the immediate vicinity of the swelling. Here, however, the symptoms were not only those of acute irreducible hernia, but they were referred to a distant, though not remote, part of the abdomen.

Two other cases are especially interesting. The first involved an acute irreducible hernia in a man of 56, occurring in the left inguinal region. The advent of irreducibility—the hernia having been reducible for a good many years—was preceded for a short interval by abdominal pain, referred to the umbilicus. Only after two or three hours, during which the patient sought relief by removing his truss, was the pain referred to the left inguinal region and then to the scrotum. On examination, there was noted not only an acute irreducible hernia but the patient had marked tenderness and rigidity above the region of the umbilicus on both the right and left sides. A diagnosis of some intra-abdominal condition other than that of hernia was considered. Dr. P. D. Allen, who operated upon the patient, left the irreducible hernia intact and opened the abdomen through a rectus incision above the level of the umbilicus, which disclosed a perforation of the stomach on its

anterior surface near the pylorus on the lesser curvature. This was sutured. The patient's hips were then elevated and the acute irreducible hernia, incarcerated but not strangulated, was reduced. The patient died after eight days from delirium tremens.

The second case, even more striking, involved a strangulated ventral hernia in the scar of a former abdominal incision for the relief of a gastric perforation five years previously. Here, again, in addition to symptoms of strangulation, were those of acute peritoneal irritation with resistance on both sides in the costal arch and both flanks. It was different, however, from the other case of hernia for the omental contents were distinctly strangulated with bloody fluid in the sac. After the relief of the strangulation, incision prolonged into the abdomen exposed a crater-like perforation of the anterior part of the stomach near the pylorus. This was closed, the hernial orifice repaired, and the patient made a very good recovery.

In both cases, the diagnosis was aided by a previous gastric history. The case of incarcerated inguinal hernia gave a history of dyspepsia, fulness of the stomach and other signs of digestive disturbance for four or five years, relieved only by the taking of bicarbonate of soda and magnesium. In the second case, the diagnosis of some intra-abdominal lesion was facilitated by the fact that the patient had had a previous perforation and that these perforations are known to occasionally recur. The presence of abdominal symptoms in addition to those of an incarcerated or strangulated hernia certainly justified thorough exploration of the abdominal cavity.

POSTOPERATIVE INFECTIONS

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MUSCAT, ARABIA

MELENEY¹ states that 15 per cent of apparently clean operations become infected. Eliason and MacLaughlin² from a survey of the literature estimate the average as 10 per cent. With our present knowledge and resources, the infection of clean surgical wounds should be much less. Evidently there is some factor of importance which is being overlooked. Bandy has shown that the sterilization of surgical dressings is not always thoroughly accomplished. The importance of careful masking of the nose and mouth is well known. Our experience in Arabia has demonstrated another factor which has proven of definite value, and attention to this point in technic has caused a great improvement in the incidence of wound contamination.

It is a mistake to think of any of our operative wounds as "sterile," *i.e.*, as completely uncontaminated by micro-organisms. The work on "Liver Autolysis in the Peritoneum," recently reported by Trusler,³ is an interesting demonstration of how far from completely aseptic most surgical wounds are. In all of them the resistance of the tissues is pitted against a certain amount of contamination, and if the contamination exceeds this degree of resistance, infection results.

Subcutaneous injections are often carelessly prepared and imperfectly sterilized, but they almost never cause infection. Evidently the tissue must

have a highly developed capacity to resist infection. But in the presence of a foreign body and trauma this capacity is greatly reduced. This was demonstrated by von Behring and Kitasato in the early investigations which led to the discovery of tetanus antitoxin. In all of our surgical wounds, the necessary placement of ligatures and buried sutures introduces foreign bodies throughout the whole traumatized area. Moreover, these foreign bodies are not only inserted as mere inert masses, whose presence constitutes a handicap to the tissues they touch, but in the knot is enclosed a mass of tissue which is killed by the pressure to which it has been subjected, and this constitutes an ideal culture media for any contaminating organism.

To these facts is to be added another, whose significance we were slow to appreciate, namely, that the infections which developed in our clean cases were apparently always associated with ligatures and buried sutures. We closed our wounds with silk, so it was impossible to blame the infection on poorly sterilized catgut. Masking was carefully observed, and the period of sterilization for dressings was doubled. It was soon apparent that we were faced with a factor which we did not appreciate. Primarily the skin of our patients is incredibly dirty, especially in the region of the groin. Our protection against dust is very poor, and on the tours, where much of our work is done, we have very little protection against the flies.

It was evident that in this situation our best technic was producing wounds contaminated slightly enough to be easily handled by normal tissues, but not always of a degree enough to be successfully handled when the contamination affected the ligatures. Our ligatures were first put in a condition of absolute bacteriologic sterility. Needles and thread are boiled for ten minutes or more. The needles are threaded with forceps, are absolutely untouched and are kept between sterile towels until the time when they are actually used. They are carefully kept from all contact with the edges of the wound, and the knots are tied with forceps. On those occasions when it seems imperative to tie a large vessel by hand, the fingers grasp the thread, at a distance from the knot sufficient to ensure that no portion of the touched thread remains in the wound.

We have had a striking opportunity to test the correctness of these ideas. Arriving in a new city, on one of our tours, we were nearly pulled from our camel by the anxious brother of a man with a strangulated hernia. Instruments were hurriedly placed in one large enamel dish, and in another towels, together with sponges cut en masse from a bolt of gauze, and left unfolded. These were boiled over two powerful Primus stoves for ten minutes. Mats on the floor served as an operating table while a sterile towel spread on the floor served as the instrument table. The patient may have gas pains afterwards, but it is the doctor who has the backache. There were an appalling number of flies present. A hemostat laid on the sterile towel did not show a square millimeter of metallic surface. It was outlined solidly in flies. A sponge showed every spot of blood covered in the same way. The opera-

tive wound was contaminated by hundreds of flies who flew into, and walked through it.

The only things kept clean were our needles and silk. They were carefully placed between folds of sterile towels till needed, and were apparently uncontaminated. The contamination of the wound had been so obvious that a few strands of silkworm gut were placed in its lower angle as a drain. The wound healed perfectly without the slightest trace of infection.

This experience gave us confidence in the correctness of the ideas formulated, and now the most rigorous care is devoted to keeping our ligatures and suture material absolutely uncontaminated. Our results have improved very markedly, and wound infections are of rare occurrence even on tours. On a recent trip we operated upon eleven herniae, one hydrocele, five goiters, performed three hysterectomies, one exploratory laparotomy and one amputation of the thigh. In none of these, nor in several miscellaneous clean minor operations, was there the slightest suggestion of any postoperative infection.

Compared to the results we previously obtained, and taking into consideration the handicaps of primitive conditions, it seems to us that a considerable advance has been made, and we feel it is entirely due to the instrumental technic employed.

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GAS GANGRENE OF WOUND OF WRIST*

ANTITOXIN TREATMENT

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Case Report.—T. P., aged 30, admitted to St. Luke's Hospital on November 3, 1934. Twenty minutes before admission he had forced his hand through a plate glass window, lacerating the right wrist, and severing the following structures: ulnar nerve, including its dorsal branch, ulnar artery, flexor carpi ulnaris, flexor digitorum sublimis and flexor digitorum profundus to both the fourth and fifth fingers. There was, also, a moderate amount of maceration of the muscular structure in the immediate vicinity of the injury.

Fifteen hundred units of tetanus antitoxin were administered, and under general anesthesia, within an hour of the accident, the dead tissue was cut away, the structures were identified, and a nerve suture performed, together with a suture of all tendons. The wound was closed with black silk and a small rubber drain was placed in the center. The wrist and fingers were placed in flexion and a molded dorsal splint was applied.

* Presented before the New York Surgical Society, October 23, 1935.

The operation was performed late in the evening. The next day there was nothing unusual about the patient's appearance or his temperature. Twenty-four hours after operation he complained of pain, and at the end of 36 hours, when his wound was dressed, there was a lymphangitis to his elbow, edema and swelling of the forearm, and a temperature of 104° F. The wound was opened and extended. At the site of all the tendon sutures, the structures were discolored but not completely gangrenous, and gas could be expressed and even seen bubbling from the wound. The wound itself was thoroughly cleansed and multiple incisions were made in the forearm and upper arm. Four hours later (40 hours postoperative) he was given 80 cc. of Lederle's Polyvalent Gas Gangrene Antitoxin intravenously. The introduction of this material was followed by some bronchial spasm. This was relieved by adrenalin. Four hours later, another 80 cc. was administered with adrenalin. His temperature fell from 104° to 103° F. and the general appearance of the wound had definitely improved by evening. Twenty hours later a third administration of 80 cc. was given intravenously, and from then on the temperature subsided and the wound improved markedly in appearance. Smears and culture taken at the time the wound was reopened showed *C. welchii*.

Wet dressings of hydrogen peroxide were applied continuously for four days, and then Dakin's dressings. Twenty days postoperatively, the wound culture was negative for gas bacillus, and again on the twenty-second day. There developed a very severe angioneurotic edema 10 days postoperatively, which was temporarily controlled by adrenalin. The wound was allowed to granulate and a Thiersch skin graft was performed on the twenty-fourth day postoperatively, with the hope of preventing extensive adhesions.

After discharge from the hospital, the hand showed definite evidence of ulnar nerve section. The ability to flex the wrist was not lost, but the flexion of the fourth and fifth fingers was definitely impaired. Within three months the sensory changes began to improve in the fingers. The lack of ability to flex the fourth and fifth fingers was, however, so distressing to the patient that he was readmitted to the hospital on June 21, 1935, and a secondary operation was performed. It was found that the flexor digitorum sublimis and profundus to these two fingers were adherent to the scar, but had not become entirely separated at the point of suture. However, they were very much stretched out. The ulnar nerve was not dissected out, but with a return of sensation and improvement in atrophy of the muscles it was felt that its continuity had not been interrupted by the infection. The flexor carpi ulnaris was intact. The flexor digitorum sublimis and profundus were dissected free and were shortened by plication. The wound was closed with drainage, and a dorsal splint applied with the fingers and wrist in flexion. Healing was by primary union after the drain was removed.

The patient now has excellent flexion of the fingers but the scar is adherent to the underlying structures and a full thickness graft or a pedicle graft will later be placed over this area.

This case has been shown for the following reasons:

(1) The advantages of prompt intravenous therapy in the case of gas gangrene which, in our opinion, prevented extensive sloughing of the sutured tendons.

(2) The importance of having adrenalin immediately available when intravenous serum therapy is administered.

DISCUSSION.—DR. HOWARD LILIENTHAL (New York) said that Doctor Morton's case was almost a duplicate of one he had presented before the Academy of Medicine in 1892.¹ A boy had cut, with a piece of glass, all the tendons of his right wrist, the median nerve and radial artery, down to the bone. One hour after the accident multiple tenorrhaphy was performed.

The wound was infected. The sutures were removed and wet dressings applied. The boy recovered but with all fingers stiff. At a subsequent operation the tendons were not cut but instead the scar was divided into strips, each strip was left attached to its severed tendon. Physiotherapy and electrotherapy were employed very early. The final condition is a useful hand with motion in all fingers.

REFERENCE

¹New York Medical Journal, 56, 516-518, 1892.

CORRECTION

June, 1936, issue, page 871, line 5, the word "anaerobic" should read "aerobic."

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THE RESTORATION OF DEFECTS IN THE SKULL

WITH SPECIAL REFERENCE TO THE MANAGEMENT OF INTRINSIC TUMORS
OF THE SKULL AND CERTAIN TYPES OF LOCALIZED OSTEOMYELITIS

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LARGE defects in the skull are a constant source of apprehension to the patient, and in some degree are a source of real danger. Apart from this aspect of the situation, defects which are not concealed by the hair, such as those involving the regions of the forehead, are extremely deforming and unsightly.

Interest in the repair of such defects was aroused during and after the Great War by the large number of patients for whom such reconstruction was desirable. During this postwar period, numerous reports of technical methods of repair and accounts of series of cases were published, but nothing radically new was evolved.

The implantation of grafts of rib cartilage from the same person, osteoperiosteal grafts to the skull from the tibia, portions of the ilium and the scapula were used. Heterografts of dead and sterilized cranial bone were transferred to the living. For small defects, trephine buttons from the outer table of neighboring bone were used to fill the gaps, and for larger areas, the outer table of skull, with pedunculated flaps of periosteum and pericranium, was chiseled off and swung into the area of the bony defect. In some cases, the rough surface was placed in apposition with the dura and, in others, it was turned toward the scalp.

A survey of the literature to determine the fate of such grafts leaves one with the wish that there were more reports of their ultimate condition. Detailed information on regeneration and absorption of bone is scanty. Conclusions drawn from experimental and clinical studies on long bones are not applicable to the skull, and very little experimental work on the skull has been done.

My own experience with strips of bone and periosteum from the tibia and with grafts from the outer surface of the skull indicates that the grafts may become solid, but that absorption of calcium progresses until the density of the graft is such that it may no longer be seen in the roentgenogram.

Deformity does not necessarily recur, although some depression returns. In place of the absorbed graft, a fibrous layer of sufficient density and firmness may remain and continue to be highly satisfactory in a cosmetic way as well as affording sound protection.

Regeneration of bone in the skull amounts to little. The opportunities to observe this after injuries and operations are numerous. Fine fissured fractures of the skull may show no roentgenologic evidence of their presence after a few months, and yet we have known a fissured fracture 1 Mm. across to persist for five years.

After osteoplastic craniotomy, the bone flaps may show bridging of bone, but the union is largely one of fibrous tissue. Trephine and perforator openings show rounding of the cut edges with the production of a small amount of new bone, but not enough to obliterate the space, which becomes filled with dense fibrous tissue.

Even careful subperiosteal craniotomies, as in the cerebellar operations on children, are not followed by the reformation of normal skull, although plaques of bone, the thickness of an eggshell, are developed at the site.

Extensive grafts of bone are time consuming. Insofar as defects in the skull can be avoided, this should be our aim. When defects are anticipated, some planning on the part of the surgeon will often permit immediate filling of the gap and will avoid secondary operations. Certain procedures have been developed in our clinic which have enabled us to avoid defects in some, and to simplify the repair in others.

Such defects of the skull are seen commonly following depressed fractures when the removal of fragments has been necessary in the interests of cleanliness; but a considerable number result from the removal of tumors involving the skull itself, or the occasional osteo-



FIG. 1.—Osteoma of the skull, before operation.

myelitis of a bone flap following craniotomy.

The removal of a bony tumor of the skull usually has necessitated the sacrifice of the involved bone so that a defect of varying size remained and operation later was necessary for the repair of the defect.

Some years ago I was consulted by a woman because of an unsightly protuberance on the right side of the forehead between the eyebrow and the hairline. It extended laterally to the margin of the temporal fossa. Roentgenologic studies confirmed the diagnosis of an osteoma. By an appropriate coiffure, the prominence could be concealed fairly well, and no surgical treatment was advised. After a lapse of some two or three years, it became apparent that, because of the progression of the growth, it would shortly reach the frontal sinuses. During this time it had extended in other directions, and increased in prominence. It reached the hairline above, and into

the anterior margin of the temporal fossa laterally. Because of its appearance (Fig. 1), the patient was quite insistent that it be removed. It was apparent that the usual procedure of complete removal of the involved bone would leave a defect which would be far more unsightly than the protrusion caused by the tumor itself. If, however, the tumor extended farther, it soon would reach the frontal sinus and complete removal would then involve the risk of infection. Some means, therefore, was sought to overcome the objectionable features of the removal. The tumor was situated in the area of bone which customarily is reflected in an osteoplastic flap to approach the pituitary region. The feasibility of making such an osteoplastic flap, remov-



FIGS. 2 and 3.—Postoperative appearance (osteoma of skull).

ing the tumor from the bone and devitalizing the bone by heat, suggested itself. It was finally decided that complete removal of the flap and restoration of the contour of the outer table by removal of the tumor with chisel and raspatory would be sufficient, and that the deprivation of circulation to the bone, which would be involved in its temporary removal, would be such as to prevent recurrence of the growth. The possible need for boiling the bone flap was considered, but this procedure was not adopted because it was thought that the coagulation of proteins within its substance would make it less readily tolerated by the surrounding tissues.

Case 1.—On February 10, 1928, a scalp incision was made of a type which has been in vogue in this Clinic since 1923. It began in the natural midline vertical crease of the forehead, about 2.5 cm. below the hairline. It continued directly up into the hairline, and almost parallel to the longitudinal sinus for a distance of 4 cm., then turned in a gentle curve down to the temporal region, just in front of the ear. The scalp and the aponeurosis of the occipitofrontalis were dissected forward, and reflected down to the region of the frontal sinus and close to the orbital ridge. An osteoplastic bone flap then was made as for intradural procedures in this region. The hinge of

the flap was placed in the right temporal fossa, and the perforator and burr openings were so located that, when connected with the Gigli saw, the entire tumor would be included in the flap. Small fragments of bone and bone dust were retained, as is our custom, for later filling in of the openings made by perforator and burr. When the bone flap was removed, the contour of the inner table was found but slightly altered and was restored by smoothing the bone. The major portion of the mass projected from the external table to the size of half an egg. With small sterile vise, raspatory and chisels the growth was removed and the contour of the skull was restored and smoothed with but little difficulty. After thorough washing with Ringer's solution, the bone flap was replaced, the perforator and burr openings were filled with bone chips and dust, and the aponeurosis and scalp were sutured in place with interrupted

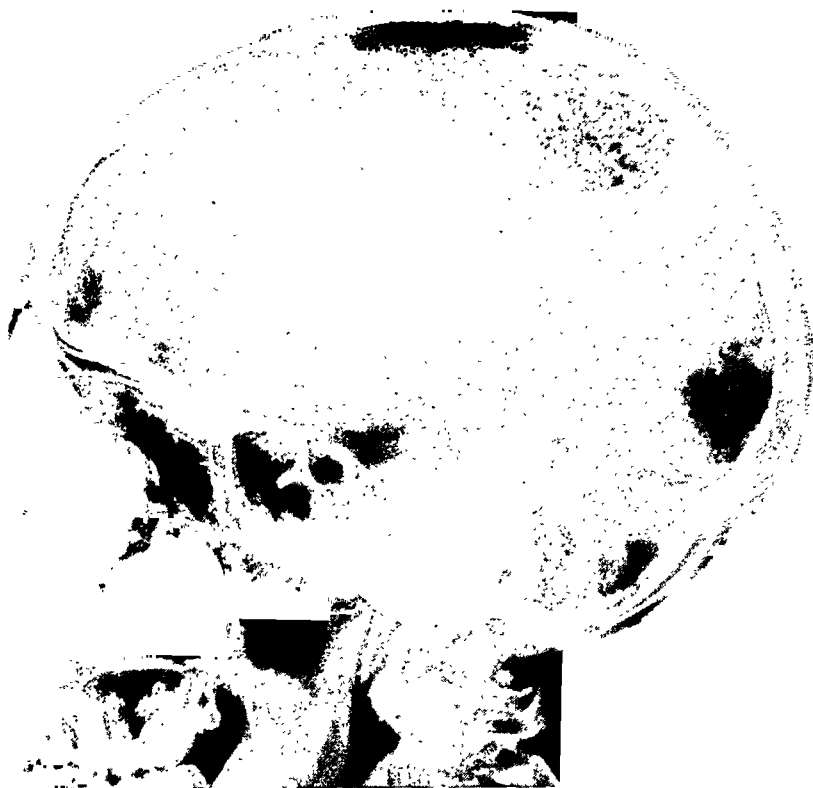


FIG. 4.—Roentgenogram of granuloma of the skull, before operation.

sutures of fine black silk. Convalescence was uninterrupted and healing was prompt and without reaction. The cosmetic result was regarded as perfect (Figs. 2 and 3). At intervals over the succeeding years, roentgenologic examinations of the area have been made, but there has been no evidence of any return of the growth, and little or no alteration has occurred in the appearance of the bone flap. In contrast to later cases in which the bone was boiled, this replaced unboiled bone shows no evidence of absorption or of sclerosis.

This experience, and the applicability of the method to other conditions encouraged us to broaden its field of usefulness. The rôle of the bones of the skull is quite different from that of bones in other parts of the body. The skeleton of the trunk and the extremities is supporting in function and provides attachments for muscles and ligaments. In the skull, the rôle of a framework to provide attachments for muscles is a *minor* one, but as a bony

case, the skull protects the cranial contents. In this manner the skull of the human being resembles the shell of the arthropods in that it surrounds the structures which it serves. The unimportance of the bones of the skull as far as the attachment of muscle is concerned, affords unusual opportunities for the treatment of neoplasms which are primary in the bone.

In the body generally, if the tissues harboring a neoplasm could be removed, the neoplastic cells killed, and the tissues serving as host to the tumor returned to the body to continue their function, the accomplishment would be ideal. Such management has proved possible in the skull, and tumors of the skull have been so treated in recent years. An ample margin of normal bone is allowed between the tumor and the area of resection. The entire area of involvement then may be removed and studied; sections for pathologic study may be obtained, and roentgenograms and photographs secured;

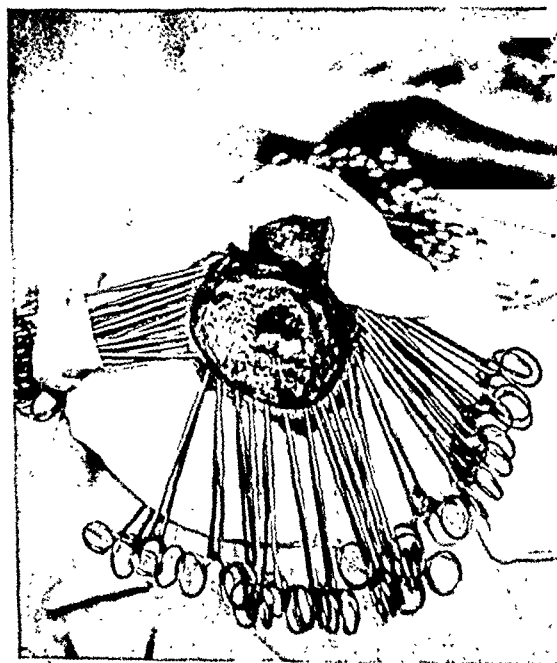


FIG. 5.—Granuloma of the skull at operation.

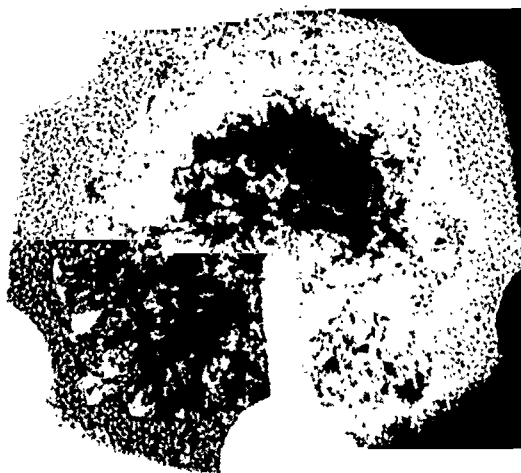


FIG. 6.—Photograph of area removed at operation for granuloma.

following this, the excessive soft tissue can be removed, the contour of both surfaces of the skull restored and, after sterilization by boiling, the bone flap can be replaced and the scalp resutured. The patient is thus left without a defect in the bone to be repaired later.

Case 2.—A patient presented himself at the University Out-Patient Dispensary because of an irregularity of the skull which he noted following an injury to his head sustained during a football game. At the time of his original injury, there had been no loss of consciousness and the game had been resumed. Some time afterward, an irregularity could be noted in the right posterior parietal region, near the parietal eminence, and as this became more marked, he sought medical advice. Upon palpation, a distinct crater could be felt, with hard edges about it. The outer surface of the bone seemed raised. It was felt that he had sustained a depressed fracture. Roentgenologic examination, however, showed a curious lace-like, moth-eaten appearance of the bone, the central area being almost destroyed, but with evidence of some proliferation of the



FIG. 8.—The amount of absorption of bone seven and one-half months after operation.



FIG. 7.—Roentgenogram showing the appearance of the replaced bone after sterilization.

Fig. 9.—Roentgenogram of the bone flap shortly after operation (case of endothelioma).



Fig. 10.—Appearance of replaced bone flap one year after operation (case of endothelioma).



bone as well as destruction of it about the margin (Fig. 4). Complete removal of the affected area would have left a huge defect of the skull.

At operation, the surrounding scalp was turned back in a large flap. The bone was exposed, and a crater 3 or 4 cm. across the center, filled by granulomatous material, was uncovered (Fig. 5). Perforator and burr openings were made at a considerable distance from the area of involvement and connected by a Gigli saw. The bone flap was removed, photographs (Fig. 6) and roentgenograms were taken, pathologic examination of the material was obtained and, after restoration of the contour of the bone, it was replaced and the scalp sutured. Healing was uneventful and there have



FIGS. 11 and 12.—Photographs showing the area of defect in the bone (case of postoperative osteomyelitis).

been no sequelae. The pathologic diagnosis on the tissue was that of a granuloma of unknown origin. Follow-up films of this replaced bone show progressive absorption (Figs. 7 and 8). Examination of the patient shows a little more depression of the area at the site of operation, but a firm support between the scalp and the dura.

Among neurologic surgeons, it is a common experience to find that the meningeal growths usually known as endotheliomata or meningiomata show a tendency to penetrate the dura and involve bone. A visible and palpable tumor frequently overlies such a growth and, in the past, complete removal of the neoplasm ordinarily has required a sacrifice of all invaded bone to prevent recurrence. Following operation, the defect in the skull often is the patient's major concern. If such invaded bone is removed en bloc, it can be treated as in Case 2. Boiling for a few minutes seems adequate for the complete destruction of all viable cells. Later roentgenograms, in one of our

cases in this group, show smoothing off of the margins of the replaced flap and spotty areas of absorption of bone (Figs. 9 and 10). Satisfactory management requires rigorous asepsis; without it one is doomed to failure.

Even in the hands of the most careful surgeons, craniotomies occasionally are followed by infection of the wound. Such a happening of course will



FIG. 13.—Appearance of the patient after replacement of the bone flap (case of postoperative osteomyelitis).

involve the immediate sacrifice of the replaced bone. On the other hand, our experiences have been a help when dealing with an infected wound after an osteoplastic craniotomy. In the following case infected bone was removed, the infection treated and later the bone was reimplanted.

Case 3.—Mrs. H. entered the University of California Hospital in September, 1931, complaining of failing vision and bitemporal hemianopsia. Investigation revealed that she was suffering from a pituitary adenoma of the chromophobe type, and operation was advised. A scalp incision of the type described in Case I was used, the scalp was reflected, a right osteoplastic flap was fashioned, and the removal of a chromophobe adenoma of the anterior lobe of the pituitary gland was accomplished. The immediate convalescence was uneventful. The sutures were removed on the fourth day. On the eighth day, a slight purpling of the scar, with fluid underneath, indicated the retention of a small amount of old blood. Puncture and aspiration revealed old blood containing a few clumps of pus cells. In spite of conservative measures, it became apparent that an extensive removal of bone would be required.

Under such conditions, the osteomyelitis usually is confined to the flap rather than

to the surrounding bone. Attempts to clear up such infections by removal with the rongeur of the neighboring portion of the bone flap must be done rather radically if the infection is to be checked, and not infrequently such a procedure is doomed to failure so that ultimate sacrifice of the entire flap is necessary. With such knowledge in mind, and with our experiences in such conditions as those mentioned above, it was considered the part of wisdom to remove the entire bone flap. The scalp was opened and the flap was taken out. The wound was irrigated thoroughly with Ringer's solution and the scalp was closed after inserting a small drain. Healing was prompt. The flap which had been removed was thoroughly washed, sterilized, and preserved for future use. In the meantime, the patient suffered from a most unsightly depression of the forehead, and the caving in of the scalp immediately above the frontal sinus was

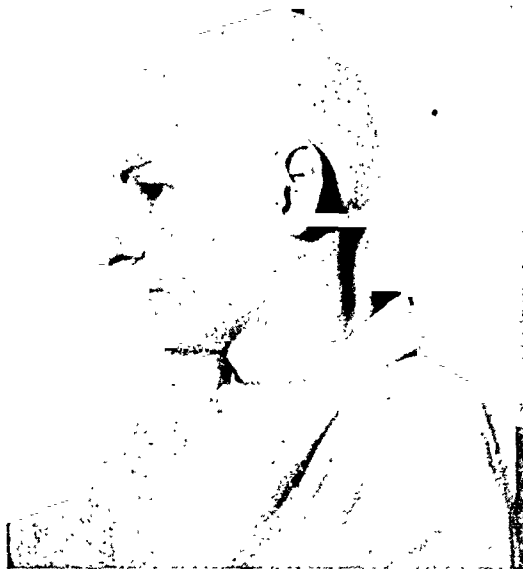


FIG. 14.—Tumor of the skull, before operation.



FIG. 15.—Appearance of the patient after operation (case of tumor of the skull).

most disconcerting (Figs. 11 and 12). A period of months elapsed during which time the wound remained completely healed without indication of infection. During the latter part of this time, the scar and surrounding area had received rather vigorous massage, without any inflammatory reaction resulting.

The wound was reopened, the rounded margins of the skull surrounding the defect were removed, and the edges freshened. The preserved bone flap, which had been reboiled, was fitted accurately into place, the perforator and burr openings were filled with small chips and the scalp was replaced and closed with layers of interrupted black silk for the galea and skin. Because of the tightness of the scar at the posterior edge, there was slight retraction, with exposure of the bone beneath over a tiny area, and for a short time we feared that this would prevent complete healing. A minor plastic operation on the scalp in this region, however, completely covered the area, healing of the wound was prompt, and there was no infection. The contour of the forehead was restored to normal and certainly no plastic operation of any of the usual types could have approached such a cosmetic result (Fig. 13). Later roentgenograms show some absorption of the replaced bone, but no recurrence of the deformity.

Case 4.—Recently a young girl presented herself because of a smooth, firm, non-tender tumor over the parietal eminence (Fig. 14). The growth had been progressive over two and one-half years. Roentgenologic studies showed what was diagnosed as a chondroma (Fig. 16). Removal of the area and surrounding normal bone in one

piece was effected. The excess tissue was removed, the bone boiled, and the flap replaced at one sitting. The growth proved to be composed of dense fibrous tissue and bone—a fibroma durum. Healing was uncomplicated (Fig. 15).

For such operative handling of the intrinsic primary tumors of the skull, or for secondary bony invasions from neighboring tumors, and in selected

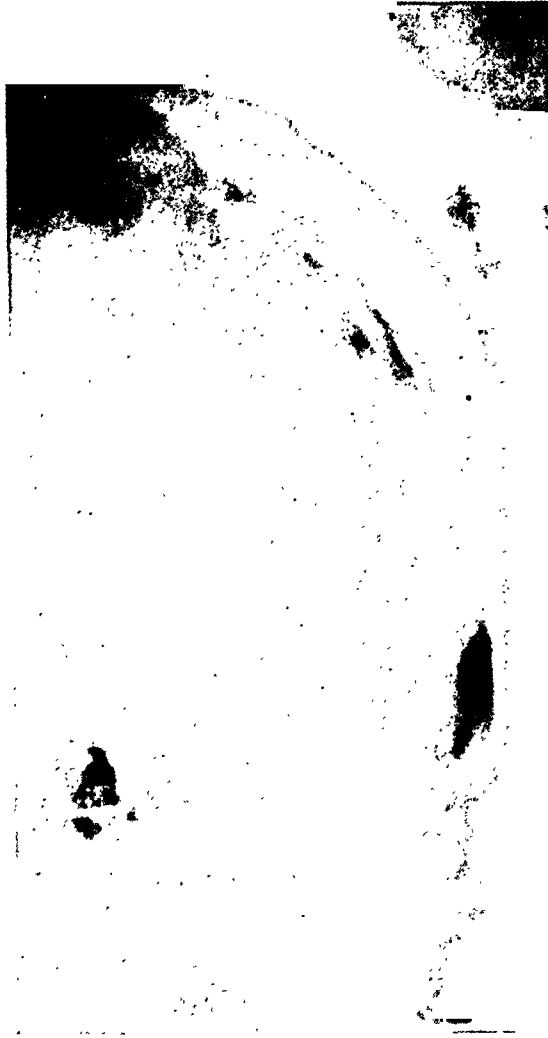


FIG. 16.—Roentgenogram of tumor of the skull.
before operation.

cases of osteomyelitis, particularly of the postoperative type herein mentioned, such procedures have given a new direction to the surgical problem. The ability to remove tissue harboring a tumor, to destroy the viability of the tumor and to replace the tissue which acted as its host, is of interest.

In the management of recent depressed fractures of the skull with badly contaminated open wounds of the scalp, the surgeon often is forced to sacrifice considerable areas of bone to prevent infection. In such cases, it is entirely practicable to save the larger pieces for replacement at a later date. In operations for closed, depressed fractures, whether soon after injury or at a later time, bone may be replaced at once after elevation.

COMPARATIVE STUDIES ON TRAUMATIC SHOCK UNDER ETHER AND UNDER SODIUM AMYTAL ANESTHESIA

AN EXPERIMENTAL RESEARCH

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For a number of years sodium amytal has been used as one of the anesthetic agents in this laboratory. Certain differences are apparent when this anesthetic is used in place of ether alone. Searles and Essex⁹ have shown that there is a concentration of the hemoglobin and cellular elements of peripheral blood in the dog when anesthetized with ether. They also demonstrated that there is a diminution in the amount of hemoglobin and cellular elements per unit volume of peripheral blood when dogs are anesthetized with sodium amytal. The spleen has been shown to be largely responsible for this alteration in the concentration of erythrocytes. As is well known, dogs under ether anesthesia salivate profusely; however, under sodium amytal anesthesia, salivation is much less marked or is absent. Because of the marked difference in the action of these anesthetics it was decided to determine by a series of experiments whether the onset of traumatic shock would be the same under each of them.

PROCEDURE.—As has been pointed out by various investigators, it is desirable to standardize the methods of producing shock if studies carried out on its mechanism, prevention, or treatment are to have significance. For this reason, in planning a number of experiments associated with the condition of traumatic shock, our first step was to develop a standard method of producing trauma. In order to test the effect of different anesthetic agents it was necessary to use the same species of animal and to use the same method in producing trauma. All experiments were done on dogs. Shock was produced by manipulation and exposure of the intestines. A series of experiments was done under ether anesthesia alone, sodium amytal anesthesia alone, and with ether and sodium amytal anesthesia combined.

All animals were fasted for 24 hours before use. A control sample of 1 cc. of blood was withdrawn from the saphenous vein, care being taken to prevent the animals from becoming unduly excited. They were then anesthetized and, 30 minutes later, a second sample of blood was taken. The abdomen was then opened, precautions being taken to reduce loss of blood to a minimum. The entire length of small intestine was delivered outside the abdominal cavity and gently manipulated by a continuous rolling motion between the hands of the operator. After 30 minutes of manipulation the

intestines were spread out on towels on the anterior abdominal wall. The intestines were turned every 30 minutes to remove fibrin and to avoid unequal exposure of the loops. The blood pressure in the femoral artery was recorded at intervals on a standard kymograph. When the blood pressure had declined to a level of 70 Mm. of mercury, the animals were considered to be in a state of shock. When the blood pressure had remained at this level for a few minutes, a third sample of blood was withdrawn from a vein in the leg.

Samples of blood were tested for cell volume by the standard hematocrit method and for hemoglobin content with the Sheard-Sanford photoelectric apparatus. In some animals changes in rectal temperature were recorded.

A series of animals was tested under the following combinations of anesthetics: One series was given ether alone; another sodium amytal alone, 50 mg. for each kilogram of body weight, while others were given 10 or 25 mg. of sodium amytal per kilogram of body weight either prior to or following the administration of ether.

Ether anesthesia was accomplished by placing the animals in a cabinet containing warmed ether vapor.⁴ After the animals were relaxed, an intratracheal tube was inserted.³ The intratracheal tube was connected to an auto-inhalation ether apparatus.³ A level of anesthesia was maintained which diminished but did not completely abolish the eyelid reflex. Sodium amytal anesthesia was administered by the intravenous injection of a freshly prepared 5 per cent solution of sodium amytal in distilled water. With amounts of 50 mg. for each kilogram of body weight, deep anesthesia was accomplished. When 25 mg. for each kilogram of body weight was administered, most of the animals were ataxic but were able to walk to the ether cabinet for the administration of ether. Occasionally this amount was sufficient to produce light anesthesia.

In order to obviate as much as possible any personal factor in the evaluation of results, one of us administered the anesthetics, and the others were unaware of the type of anesthesia employed until after the different series of experiments were completed.

RESULTS.—Ether Anesthesia Only.—Manipulation of the intestines was carried out under ether anesthesia alone with seven animals. The average time of the onset of shock was three hours and 53 minutes after the beginning of intestinal manipulation. The average time of death in this series was five hours and 53 minutes. After 30 minutes of ether anesthesia, before the abdomen was opened, the average concentration of hemoglobin was 120.2 per cent as compared with the control determinations of 100 per cent. After shock developed, the average concentration of hemoglobin was 130.3 per cent. The rectal temperature in this group under ether anesthesia averaged 39.1° C.; this declined to 36.5° C. at the time of shock and registered 34.5° C. just prior to death.

Sodium Amytal Anesthesia Only.—In a series of three animals under sodium amytal anesthesia alone (50 mg. per kilogram body weight) the

average time of the onset of shock was 11 hours and 33 minutes after the beginning of intestinal manipulation. The average time of death was 14 hours and 44 minutes. After 30 minutes of sodium amytal anesthesia, the average concentration of hemoglobin was 87.8 per cent of normal control samples. At the time of shock the average concentration of hemoglobin was 137.7 per cent. The average rectal temperature under sodium amytal anesthesia was 38.6°C .; this declined to 35.5°C . at the time of shock and registered 33.5°C . just prior to death.

Combined Ether and Sodium Amytal Anesthesia.—Five animals were tested as follows: After the administration of 25 mg. of sodium amytal for each kilogram of body weight a period of 15 minutes was allowed to elapse. The animals were then etherized. After 15 minutes of ether administration the usual manipulation of the intestines was carried out. The average time of the onset of shock in this series was ten hours and 31 minutes. The average time of death was 13 hours and 31 minutes. The concentration of hemoglobin after 15 minutes of sodium amytal anesthesia averaged 86.3 per cent of control samples. Fifteen minutes after the addition of ether the average concentration of hemoglobin was 105.7 per cent. At the time of shock the average concentration of hemoglobin was 136.2 per cent.

Two animals were tested in which 25 mg. of sodium amytal per kilogram of body weight was given after 15 minutes of ether anesthesia. Under this anesthesia shock developed in one animal six hours and 25 minutes after the beginning of intestinal manipulation and the dog died after ten hours and 15 minutes. Shock developed in the other dog 11 hours and 25 minutes after the beginning of intestinal manipulation and it died after 15 hours and five minutes. In these animals the concentration of hemoglobin was 119 per cent of normal control samples after 15 minutes of ether anesthesia. Fifteen minutes after the administration of sodium amytal the concentration was 114 per cent, indicating that after the concentration had occurred under ether anesthesia, sodium amytal was not effective in lowering this concentration as greatly as when sodium amytal was used alone.

Two animals were tested in which only 10 mg. of sodium amytal per kilogram of body weight was administered 15 minutes prior to the administration of ether. Shock developed in one case in three hours and ten minutes and the animal died four hours and 55 minutes after the beginning of intestinal manipulation. Because the first animal reacted in a manner similar to those under ether anesthesia only, and the other reacted in a manner similar to those under sodium amytal anesthesia only, it was decided to confine the major portion of this study to the larger doses of sodium amytal. However, our data indicate that the minimal dose of sodium amytal necessary to prolong the onset of traumatic shock induced by intestinal manipulation is between 10 and 25 mg. per kilogram of body weight.

The time of the onset of shock and the time of death for the foregoing series of animals is represented in a bar diagram (Chart 1). Changes in the concentration of hemoglobin in these series are recorded in Chart 2.

Comment.—Reports by various workers on the problem of traumatic shock have indicated little difference in the results following trauma to the limb under different anesthetic agents. Parsons and Phemister,⁶ working with dogs, used ether alone, ether and morphine, barbital alone, and barbital and morphine. When morphine was used in combination with the other

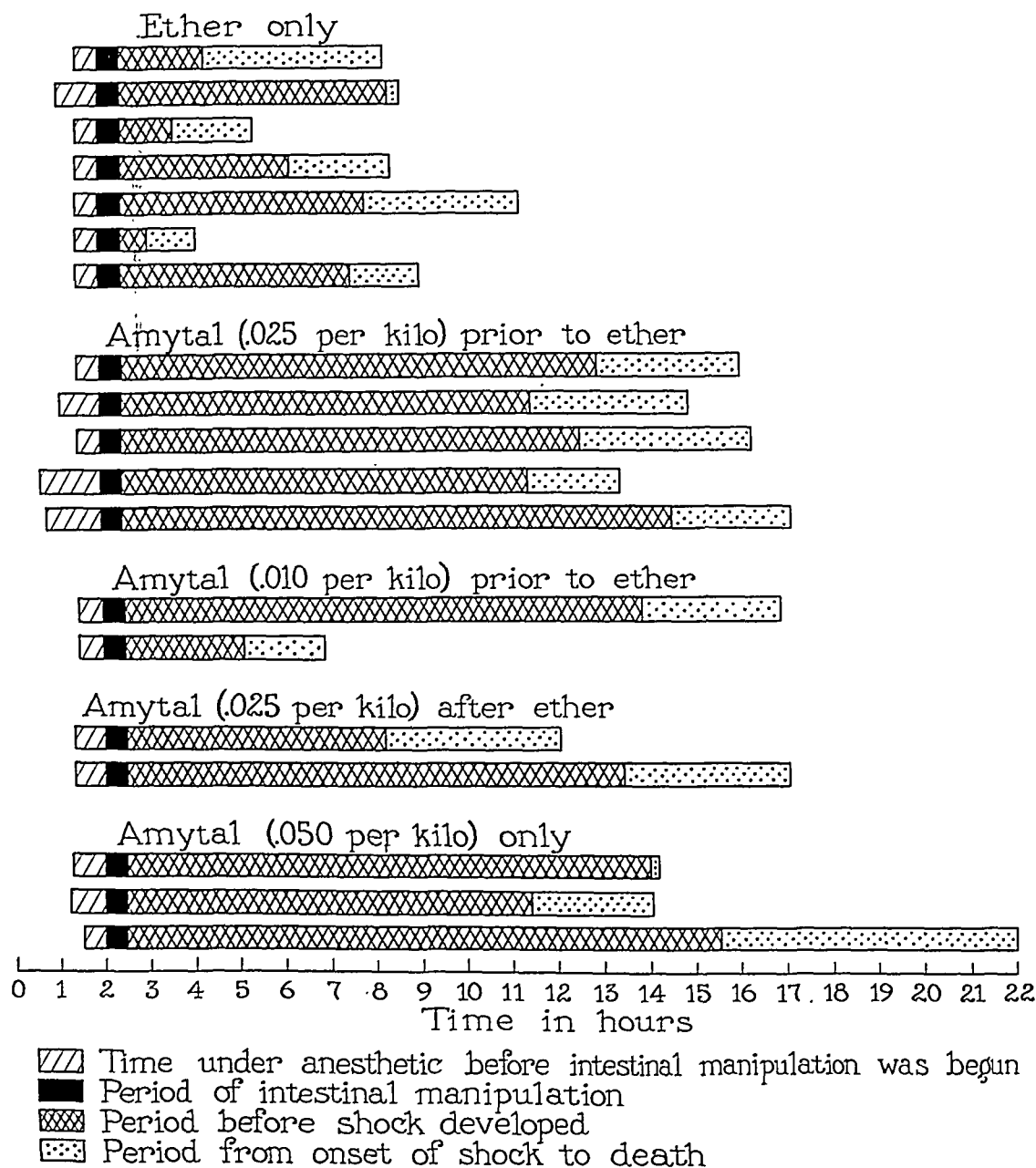


CHART 1.—Graphic representation of the data on each series of experiments with ether or amytal alone or combinations of these anesthetics.

agents just mentioned, they noted that the blood pressure was slightly lower than when these agents were used alone. Otherwise they noted no significant difference in the time of the onset of shock under these anesthetic agents following standardized trauma to the hind limbs. Roome, Keith and Phemister⁷ used sodium barbital anesthesia and ether anesthesia and obtained similar results with these two anesthetics. Marshall,⁵ Crile,² and Cannon¹ reported

that the blood pressure was much lower under ether or chloroform anesthesia than under nitrous oxide anesthesia.

It is apparent from our findings that when sodium amytal anesthesia is used alone, or when sodium amytal is given preliminary to ether anesthesia in the amount of 25 mg. per kilogram of body weight of the dog, the time of the onset of shock and the time of death is delayed markedly after trauma and exposure of the intestines. The mechanism by which sodium amytal pro-

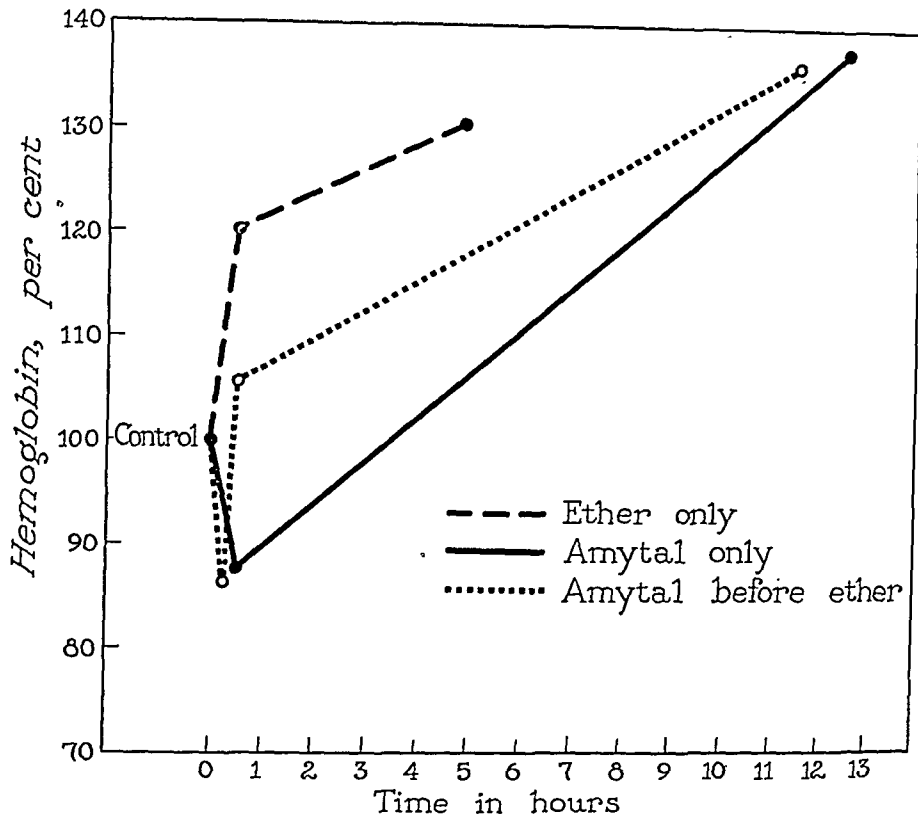


CHART 2.—The average values of hemoglobin obtained in a series of experiments with amytal or ether anesthesia used alone or in combination.

duced such a result is an open question; however, we wish to mention a few observations that may have a bearing on the matter. We have noted that salivation does not occur under sodium amytal anesthesia alone. Those animals receiving preliminary medication with sodium amytal did not salivate. In cases in which ether alone was used, marked salivation occurred, but within an hour after the administration of sodium amytal salivation ceased and the mouth was dry throughout the remainder of the experiment. Prevention of loss of fluid in this way is considered of importance in maintaining the total amount of fluid in the general circulation. Loss of fluid from the surface of the traumatized intestines was much less rapid under sodium amytal than under ether anesthesia. It is our belief that sodium amytal delays this exudation. The amount of fluid lost from the circulation was apparently the

same in all series at the time of shock, as shown by the concentration of hemoglobin at that time. This indicates that sodium amytal probably acts in such a way as to delay the loss of fluid from the circulation following trauma to the intestines, and that thereby the onset of shock is retarded. For this reason we do not consider that this anesthetic agent would necessarily be of value after shock has developed. No explanation is at hand to explain the physiologic mechanism by which sodium amytal delays the loss of fluid following this type of trauma.

After manipulation of the intestine had been carried out for 30 minutes, there was a marked difference in the appearance of the bowel, depending on the anesthesia employed. Under ether anesthesia alone the bowel was slightly cyanotic and the exudation of fluid was sufficient to dampen several layers of cloth spread under the intestinal loops. After the same degree of trauma under sodium amytal anesthesia, alone or in combination with ether, the intestines were pink in color, appearing only moderately inflamed and the exudation of fluid was less rapid.

It is a well known fact that considerable fluid is lost from the body through respiration. The respiratory rate under ether anesthesia alone varies from 30 to 40 per minute. Under sodium amytal anesthesia alone it was from 8 to 14 per minute. In the experiments in which sodium amytal was administered prior to the inhalation of ether, or 15 minutes thereafter, the respiratory rate was from 30 to 40 per minute. Since the loss of fluid through respiration was not measured, a definite statement cannot be made as to the effects of the two anesthetic agents in this regard.

SUMMARY

Under a standard method of producing traumatic shock in the dog we have found that sodium amytal anesthesia alone, or sodium amytal preliminary to ether anesthesia, results in a definite delay in the onset of shock and of death. Loss of fluid from the circulation in the form of saliva and in the form of exudate from the surface of the traumatized intestine is less rapid when sodium amytal has been administered.

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MODIFIED DORSAL SYMPATHECTOMY FOR VASCULAR SPASM (RAYNAUD'S DISEASE) OF THE UPPER EXTREMITY*

A PRELIMINARY REPORT

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THE end-results of cervicodorsal sympathetic ganglionectomy for vascular spasm (Raynaud's disease) of the upper extremity have not been satisfactory. The reasons for failure of this type of operation have been discussed in some detail in previous communications.^{1, 2} This evidence will be briefly reviewed before presenting a modified dorsal sympathectomy which at the time of writing gives evidence of being a satisfactory solution of the problem.

It is generally agreed that the efferent vasoconstrictor fibers to the upper extremity leave the lateral horn of the dorsal cord, pass out by way of the anterior roots to enter the mixed nerves, then leave the nerves by way of communicating white rami to enter the dorsal sympathetic trunk. They then pass a variable distance along the trunk and form synapses in certain of the ganglia. They then leave these ganglia as postganglionic fibers and pass by way of other communicating gray rami to the cords of the brachial plexus. From here they are distributed to the blood vessels, leaving the mixed nerves a short distance from their endings in the vessel wall. Probably all of the synapses concerned lie in the inferior cervical and the first and second dorsal sympathetic ganglia although there may possibly be a few in the third dorsal ganglion.

In our earlier cases the upper extremity was sympathectomized by removing the second and third dorsal ganglia. The immediate result was excellent, but in the course of six months to a year signs of vascular spasm returned. Along with this was noticed, to a lesser degree, return of perspiration. Other early cases were sympathectomized by removal of the first and second dorsal ganglia. Again the immediate result was excellent but the same evidence of recurrence appeared in the course of six months to a year. Our inclination, at that time, was to explain these delayed recurrences on the basis of regeneration of nerve fibers. Accordingly another group of cases was sympathectomized by a more extensive operation in which the inferior cervical, the first and second dorsal sympathetic ganglia and intervening trunk were excised. Again recurrence of vascular spasm was noted but instead of appearing in six months to a year, in some instances it appeared in about two weeks. This obviously could not be explained on the basis of regeneration of nerve fibers as Horner's syndrome and a complete sudomotor paralysis persisted.

* Presented before the Boston Surgical Society, November 4, 1935.

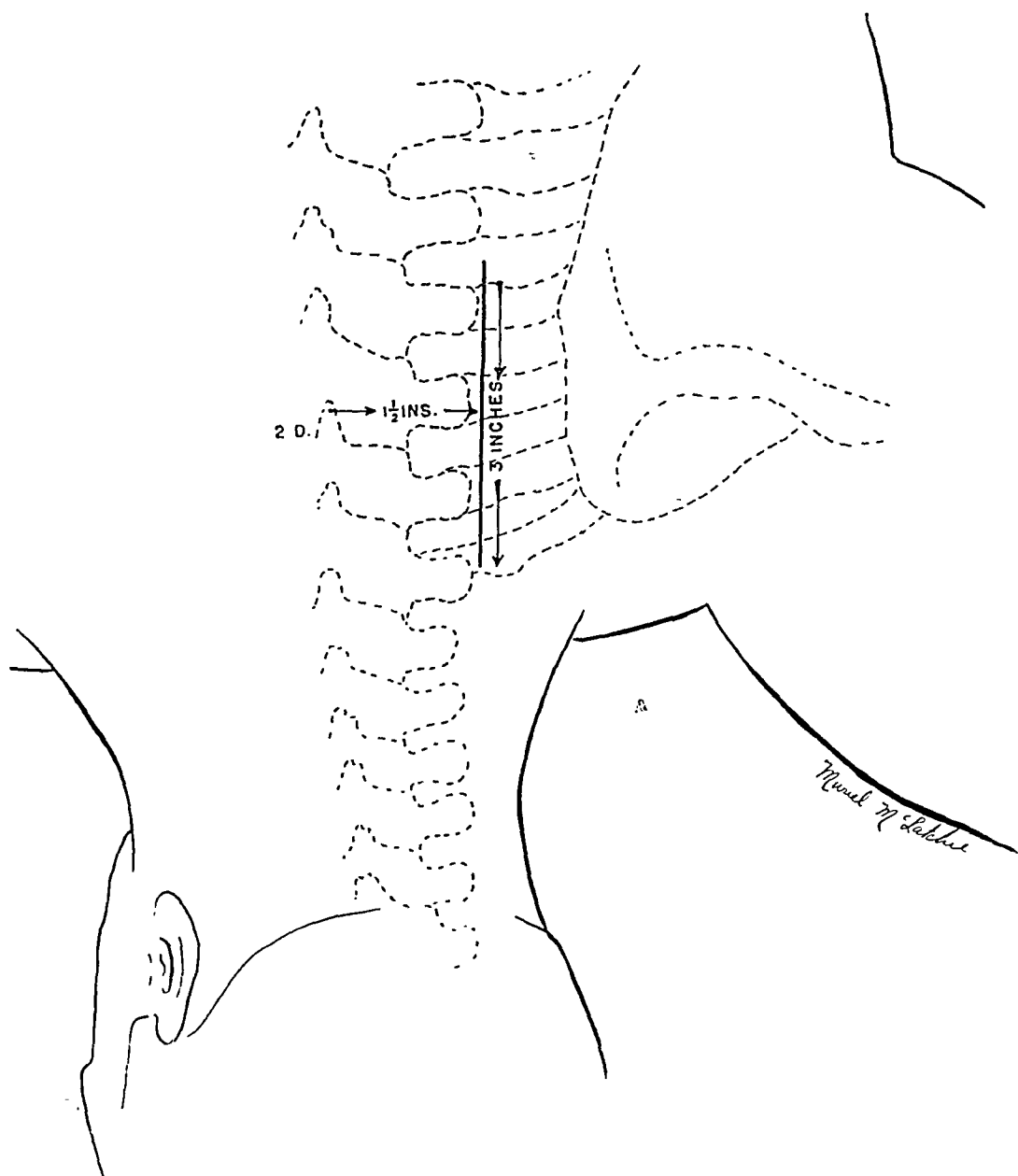
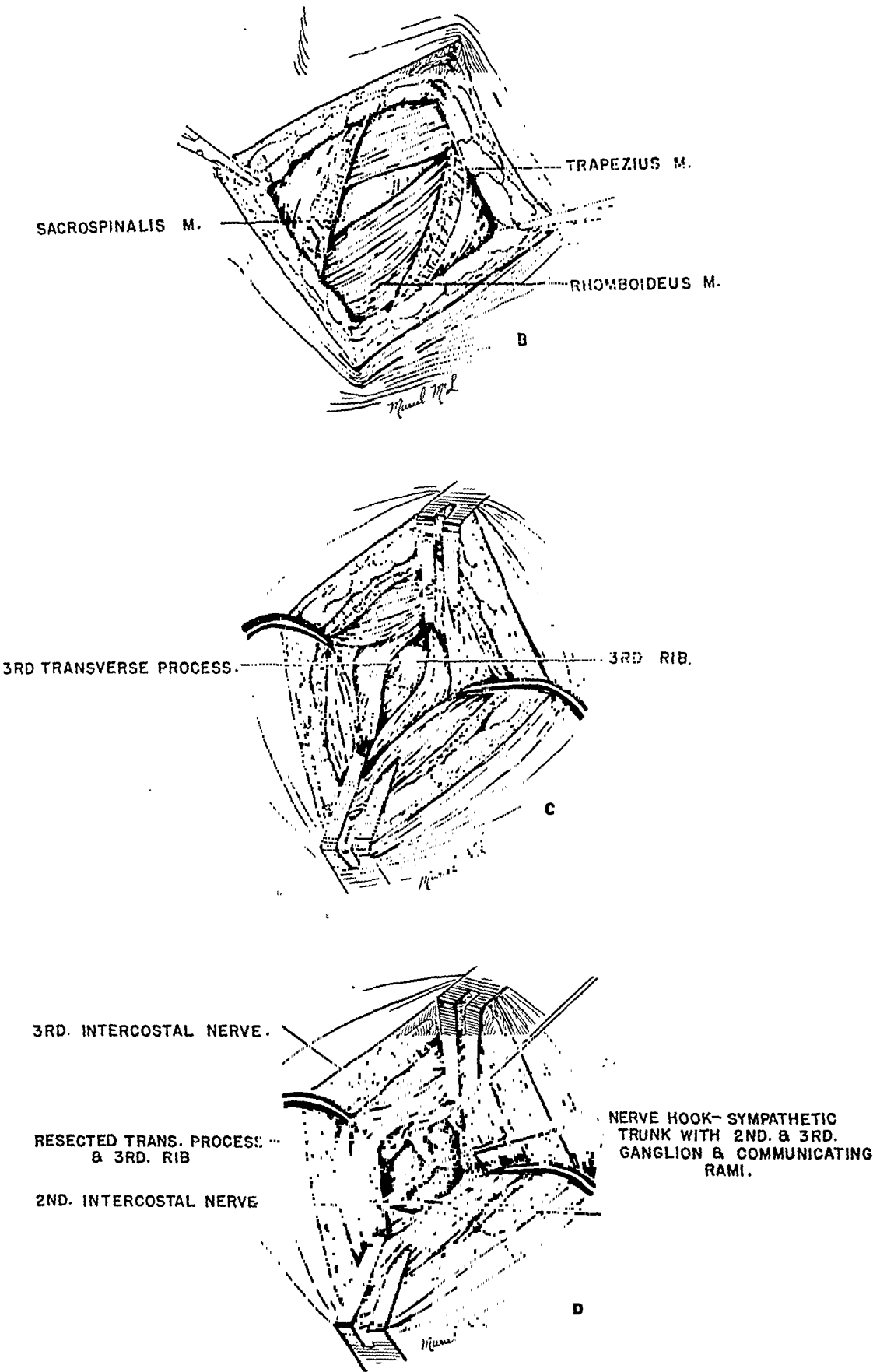


FIG. 1.—Illustrating (A) Position of incision with reference to spine and shoulder girdle. (B) Incision carried down through trapezius muscle exposing rhomboid muscles and sacrospinalis group. (C) Sacrospinalis muscle split vertically over line of transverse process exposing third rib and transverse process. (D) Third rib and transverse process have been resected, the intercostal nerves and sympathetic trunk identified, and lung and pleura dissected back from bodies of vertebrae. Illustrations B, C, and D were drawn from the right of patient's head looking to the left and toward the foot of table.

DORSAL SYMPATHECTOMY



Extensive animal and clinical experimental study was then carried on to determine the cause of recurrence of vascular spasm after ganglionectomy.^{1, 2} It was found that this type of vascular spasm was due to the action of adrenalin on the vessel wall; that it took between ten days and three weeks for this phenomenon to become well marked after extensive ganglionectomy; and that this spasm could be inhibited in animals by excision of one adrenal gland and denervation of the other. It was also shown in rabbits and in monkeys that the adrenalin sensitivity of smooth muscle in the arteriolar walls was much less increased when the preganglionic vasoconstrictor neu-

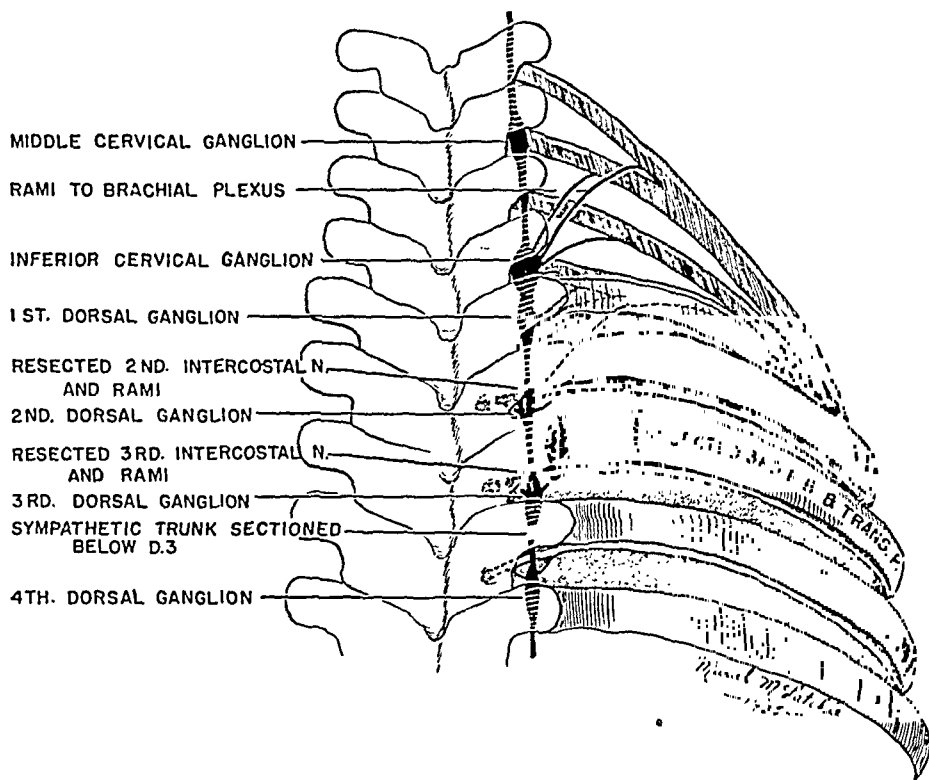


FIG. 2.—A diagrammatic representation of the operation, showing resected portion of third rib and transverse process, resected second and third intercostal nerves with accompanying rami, and sectioned sympathetic trunk below the third dorsal ganglion. Enough mobility is produced in this way so that the upper end of the sectioned sympathetic trunk can be brought into the incision, and sutured without tension to the muscles of the back. This should help prevent regeneration of nerve fibers.

rons alone were severed.³ Grant⁴ has recently published quite similar conclusions and Hampel⁵ has quantitatively measured the contraction of the denervated smooth muscle in the nictitating membrane of the cat when stimulated by adrenalin. His experiments show that smooth muscle denervated by degeneration of the postganglionic fibers is over twice as sensitive to adrenalin as it is after destruction of the preganglionic portion of the sympathetic pathway.

From these facts it seemed apparent that vascular spasm after ganglionectomy was probably due to degeneration of the postganglionic fibers and the consequent extreme sensitivity to adrenalin which is known to occur when this takes place. The cells of origin of the postganglionic neurons lie in the

sympathetic ganglia and the fibers presumably will degenerate if the ganglia connected with the roots of the brachial and lumbosacral plexuses are removed. Lumbar ganglionectomy had always been successful in relieving



FIG. 3.—(Case 2, Table I.) Showing advanced changes in hands, face and neck due to extensive scleroderma. Note the drawn expression of the face which is characteristic of the late stages of this disease. Also note the shortening of the finger tips due to loss of bone. The skin of the hands is stiff and rigid, causing marked limitation of motion. These changes took place over a period of five years.

vascular spasm in the lower extremities. The above explanation at first seemed contradictory until it was pointed out by Dr. James C. White that the postganglionic neurons to the sciatic nerve probably originate in the lowest

TABLE I

Name	Age	Sex	Duration of Symptoms	Evidence of Vascular Spasm	Evidence of Vascular Obliteration	Operation	Interval Since Operation	Result
1. Siracusa BM 17064	21	M.	2 yrs.	Marked blanching, cyanosis, slight moisture, no temperature rise on novocain block	Striking fibrosis of fingers with scleroderma	Left dorsal sympathectomy, resection D ₂ , section of trunk below D ₂	11 mos.	Hand pink, dry; temperature rise about 15° F., occasional slight blanching spells
2. Sclafoni 343387	41	F.	5 yrs.	Cyanotic hands, 10° F. rise on novocain block	Marked fibrosis; scleroderma hands, neck, face; loss terminal phalanges	Right dorsal sympathectomy	9 mos.	Hand pink, dry, warm; temperature rise 10°-15° F., slight momentary cyanosis
3. Lazaropolous 346502	18	F.	8 yrs.	Marked cyanosis, cold moist hands, novocain block not done	Marked fibrosis; scleroderma hands, face, neck	(1) Right dorsal sympathectomy. (2) Left dorsal sympathectomy	6 mos. 3 mos.	Hands pink, dry; temperature rise about 10° F., occasional momentary color change
4. Ganno 330674	37	F.	8 yrs.	Marked cyanosis, moisture, hands	Extensive fibrosis; scleroderma face, neck, hands; loss many terminal phalanges	Right dorsal sympathectomy	4 mos.	Hand pink, dry; 5°-10° F. warmer, does not change color, improvement in scleroderma hand, right side face, neck
5. Gilbert BM 16374	45	F.	15 yrs.	Marked cyanosis, no temperature rise on novocain block	Striking fibrosis; scleroderma hands, neck, face; destruction terminal phalanges by roentgen ray, ulceration several fingertips	Left dorsal sympathectomy, resection D ₂ , section of trunk below D ₃	4 mos.	Hand pink, dry, without color change; slight temperature elevation—2°-3° F. fingertips, about 5° F. in palm
6. Walsh 348518	23	F.	1 yr.	Marked blanching, cyanosis, moisture, temperature rise	Slight scleroderma, ulcers several fingertips, rheumatoid	(1) Right dorsal sympathectomy. (2) Left dorsal	4 mos. 4 mos.	Hands pink, dry, warm, no color change, surface temperature

lumbar and the sacral sympathetic ganglia. Consequently when the second and third lumbar ganglia are removed—the usual operation to sympathectomize the lower extremity—we are probably cutting largely preganglionic fibers to the lower extremity. From experimental evidence given in the preceding paragraph this should result in a far lesser sensitization of the foot to circulating hormones.

Based upon the foregoing facts and theories a modified dorsal sympathectomy has been employed in a small group of cases having vascular spasm of the upper extremities. The technic (Fig. 1) consists of a vertical

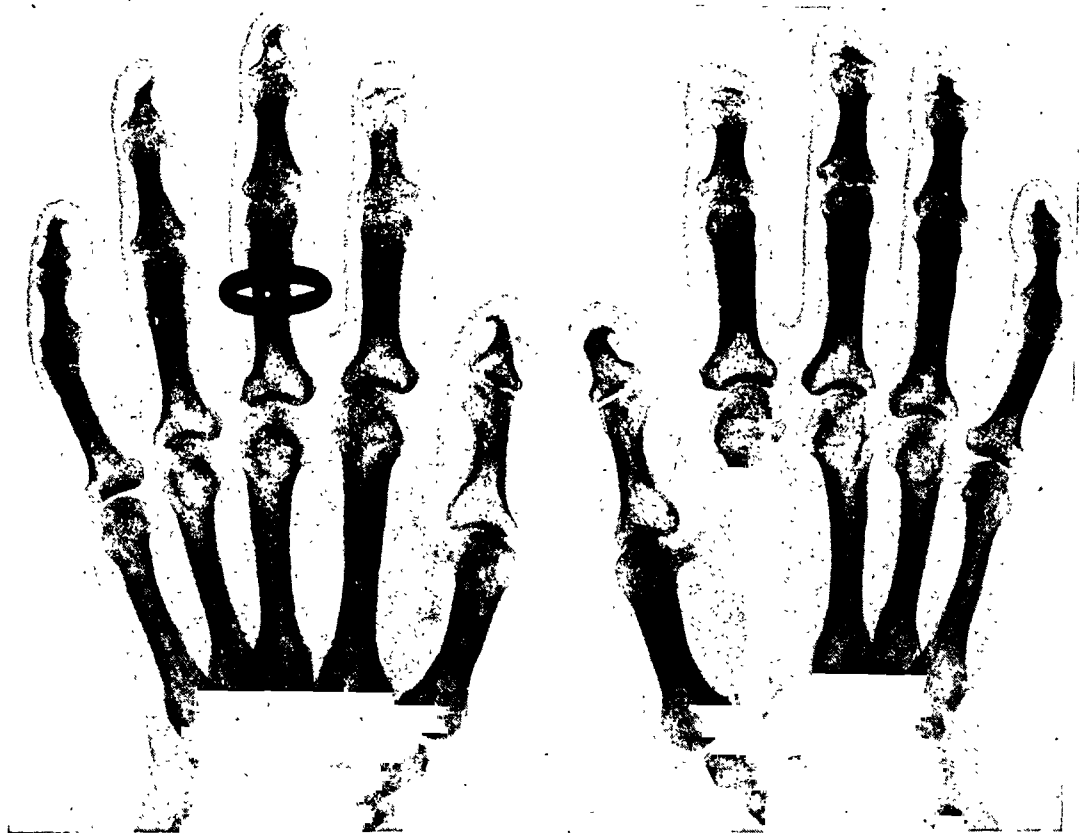


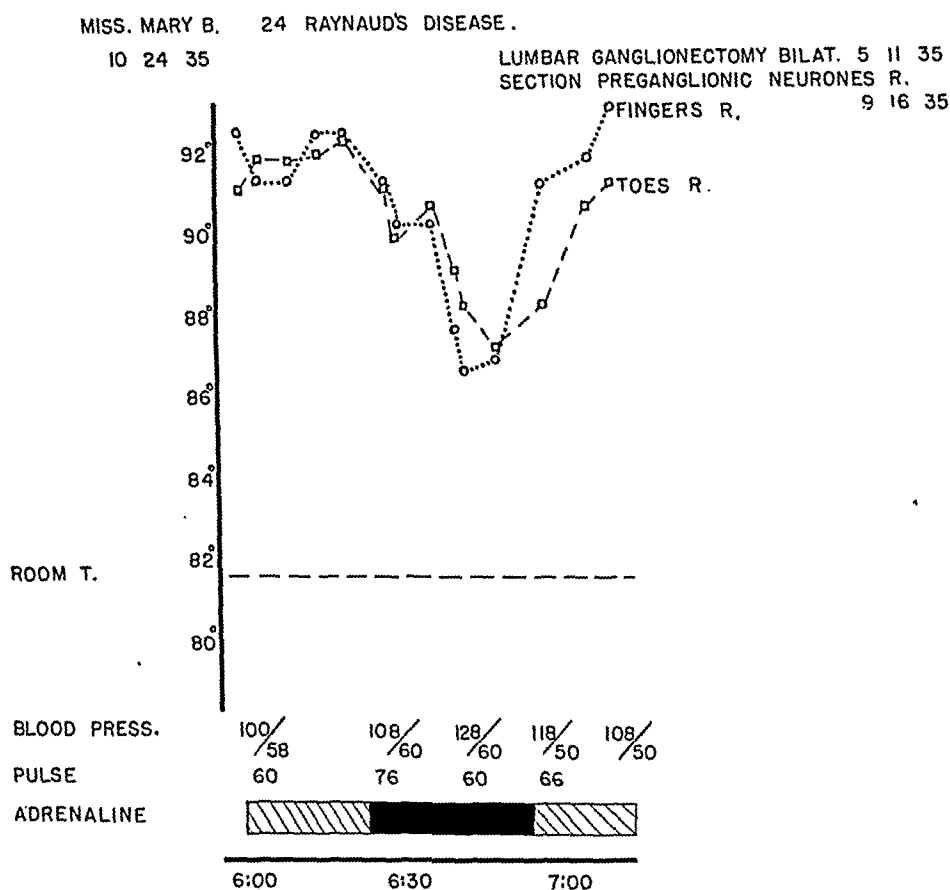
FIG. 4.—(Case 2, Table I.) Roentgenogram showing destruction of terminal phalanges of several fingers of each hand. This results in short blunt finger tips, and is characteristic of the end-result of prolonged vascular spasm. Often calcium deposits can be seen in the soft tissues. This has not occurred in this case, but is another typical change often seen.

paramedian incision about 6 cm. long, 3 cm. from the midline, centering the incision opposite the second dorsal spinous process. The inner inch of the third rib and corresponding transverse process are resected. The inner inch and one-half of the second and third intercostal nerves are resected from the intervertebral foramen outward (Fig. 2). The dorsal sympathetic trunk is identified between the second and third dorsal ganglia, is sectioned just below the third dorsal ganglion, and the upper end of the sectioned trunk is brought out of the thorax and sutured without tension to the muscles of the back.

The intercostal nerves are resected in order to guarantee a complete ramisectomy and also as an additional safeguard against regeneration. This

results in a zone of anesthesia about the thorax which becomes so narrow in a few months that it is a matter of no importance. The axillary region remains quite anesthetic and perspiration is inhibited. In two cases there has been a slight variation in the surgical technic. In both, only the second intercostal nerve was resected. In one of these the sympathetic trunk was also sectioned below the second dorsal ganglion and in the other below the third dorsal ganglion. The immediate results are satisfactory in each instance although it is felt that resection of both the second and third intercostal nerves and section of the sympathetic trunk below the third dorsal ganglion is theoretically a better procedure.*

By this operation all possible sympathetic connections between the dorsal



GRAPH 1.—(Case 7, Table I.) Showing the same temperature fall in the sympathectomized hand and foot in response to intravenous adrenalin (1 to 250,000). A fall of about 6° F. is recorded. There is no clinical evidence of sensitivity to adrenalin in either extremity. This is the usual finding in an extremity which has been sympathectomized by section of preganglionic fibers. If postganglionic fibers were sectioned in this case, a temperature drop of about 15° F. would be expected under similar conditions.

cord and the brachial plexus are severed except those which might be contained in the first dorsal nerve. This of course cannot be divided as motor and sensory paralysis in the arm would result. We believe that only preganglionic fibers are divided in this operation and that the postganglionic fibers to the arm are left intact.

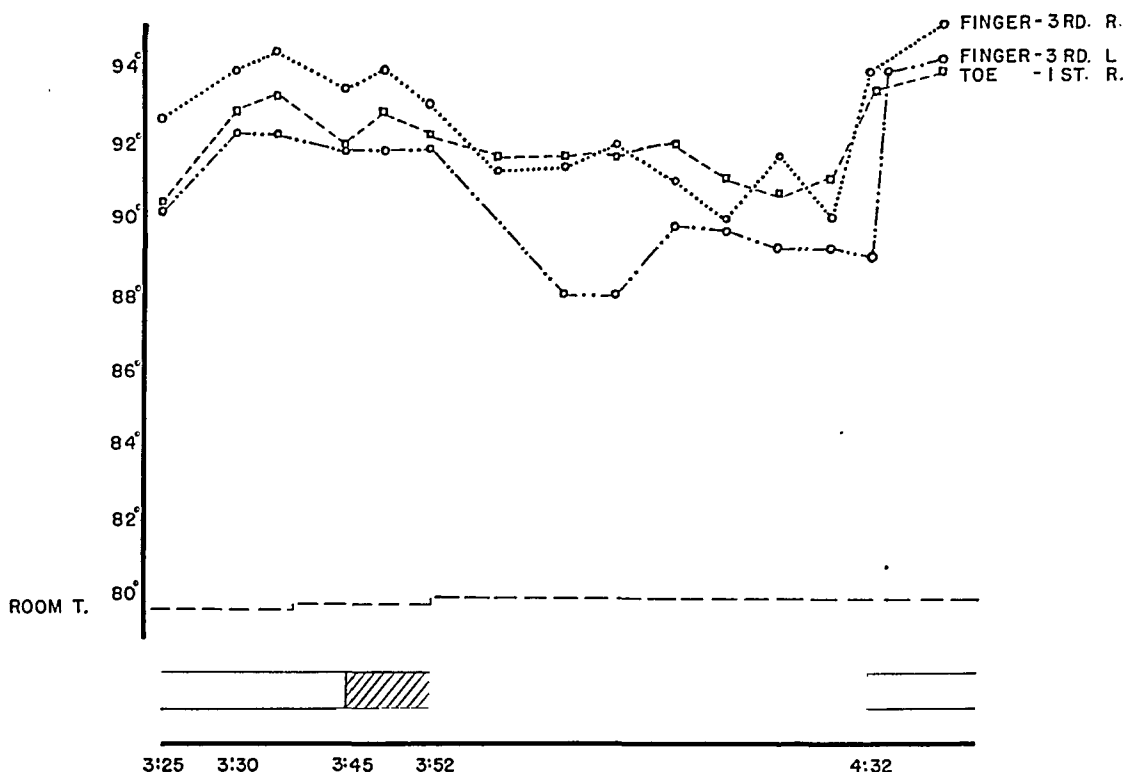
The clinical results to date would indicate that few if any efferent sympathetic fibers to the hand pass over the first dorsal nerve. Further corroboration of this is found in unpublished experimental work by Dr. James C.

* See last paragraph in article for slight change in technique of operation.

White, who has found that it is necessary to divide the dorsal anterior roots as low as the eleventh or twelfth in order to completely sympathectomize the upper extremity of a monkey, while the upper two or three roots seem of little importance. It would seem probable that in the human, efferent sympathetic impulses to the upper extremity arise from nearly the entire dorsal cord, the first segment carrying few if any pathways.

To date, December, 1935, 16 upper extremities have been sympathectomized in 11 patients (Table I). Eight of the cases were well advanced in the disease with associated scleroderma (Fig. 3), fibrosis of the soft tissues of the fingers, and often with destruction of the terminal phalanges (Fig. 4). In some instances no preoperative surface temperature rise could be obtained

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GRAPH 2.—(Case 9, Table I.) Intravenous administration of adrenalin (1 to 250,000) is given at the rate of about 60 drops per minute. This is shown by the solid black rectangle in the diagram. A preliminary period of intravenous saline at the same rate is shown by the cross-hatched rectangle. All three extremities show only a very slight temperature fall during the experiment. The left hand shows the greatest temperature drop (4° F.), while the right hand and foot show little change. The left hand and right foot are completely sympathectomized. The right hand is incompletely sympathectomized.

by novocain block. All have shown a surface temperature rise after operation, this elevation ranging between 5° and 20° F. at the tips of the fingers. The temperature rise is dependent upon the amount of organic occlusion already present. In all but one instance (footnote, Table I) the hands appear to be very completely sympathectomized, being pink in color and dry. In some cases momentary discoloration of the fingers has appeared at times after operation, but this has not been of any practical importance. Two cases with associated scleroderma and pigmentation of the skin of the

neck, face and forehead have shown a striking decrease in the pigmentation on the operated side in the course of four to six months, with softening and increased pliability of the skin. Perspiration is abolished over the head, face and neck as well as the axilla and extremity. A Horner's sign is not produced by this operation as was the case when the inferior cervical or first dorsal ganglion was removed.

The first operation in this series was done January 24, 1935, 11 months ago. By this time recurrence of vascular spasm would usually be clinically obvious following the operation of ganglionectomy. It is a little early to conclude that recurrence of vascular spasm could not take place at a later date due to regeneration of nerve fibers.

Three cases have been tested by the intravenous administration of adrenalin in a dilution of 1 to 250,000. The surface temperature fall is comparable to that obtained in a sympathectomized foot. Two of these cases (Graphs 1 and 2) also have had both feet sympathectomized and the temperature fall in the sympathectomized hands and feet is almost identical.

From a clinical point of view this modified type of sympathectomy is not followed by recurrence of vascular spasm due to the action of adrenalin on the blood vessels in the sympathectomized area. This was the greatest drawback to the operation of cervicodorsal ganglionectomy and rendered that operation unsatisfactory in our opinion.

Since writing this paper my attention has been called to a similar operation reported by Telford.⁶ He uses an anterior approach, dividing the white rami between the second and third intercostal nerves and the corresponding sympathetic ganglia, and sections the sympathetic trunk below the third dorsal ganglion.

At the present time (Aug. 1, 1936) the series has increased to 33 upper extremities in 23 patients. Several further instances of incomplete sympathectomy have been encountered as described in Table I, Case 9, and Graph 2. The most likely explanation is failure to interrupt all of the rami running from the second and third intercostal nerves to the sympathetic trunk. Failure to section the trunk itself would also produce the same result, but seems a less likely probability. For this reason the technique of operation has been altered so that the dissection of the intercostal nerves is carried into the intervertebral foramen, dividing the dural attachments, and sectioning the anterior and posterior roots as well. In this way it is impossible to overlook any white rami which might arise close to the intervertebral foramen. In the more recent cases, this technique has been followed with uniformly satisfactory results.

CONCLUSIONS

(1) A modified dorsal sympathectomy for relief of vascular spasm of the upper extremity is described.

(2) We believe that only preganglionic fibers are sectioned in this operation and that the postganglionic fibers are left intact.

(3) No clinical evidence of recurrence of vascular spasm has been noted. The longest interval since operation is 11 months.

(4) The surface temperature fall in the hand in response to intravenous administration of adrenalin in a dilution of 1 to 250,000 is comparable to that observed in the foot after lumbar ganglionectomy.

(5) If recurrence of vascular spasm does not take place at a later date due to regeneration of nerve fibers this should be a satisfactory method of eliminating vascular spasm in the upper extremity.

(6) It seems only reasonable to predict that the best results will be obtained when operation is done before advanced fibrosis with the associated vascular occlusion takes place.

(7) The cause of recurrence of vascular spasm after cervicodorsal ganglionectomy is reviewed.

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RESECTION OF THE PRESACRAL NERVE FOR DYSMENORRHEA AND PELVIC PAIN

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THE present report is a review of eight cases of dysmenorrhea relieved by section of the presacral nerve.

Historic Survey.—Jaboulay¹⁷ made the first attempt to relieve pelvic pain by dividing the pelvic sympathetic fibers through a retrorectal approach. A year later, Ruggi^{20, 27} added to this investigation by advocating resection of the utero-ovarian plexus via a transperitoneal route. The results of these operations met with partial success, but little more was achieved until Leriche^{22, 23} introduced peri-arterial sympathectomy of the internal iliac artery as a means of relieving pain in cases of functional dysmenorrhea. The latter procedure was utilized by Cotté^{6, 7} and Michon.²⁴ In 1925, Cotté introduced the operation of resection of the superior hypogastric plexus, called the presacral nerve of Latarjet and Bonnet,²⁰ for functional dysmenorrhea and reported favorable results. He listed six indications for the use of his method: (1) pelvic neuralgia, (2) vaginismus, (3) dysmenorrhea, resistant to ordinary methods adopted for its relief, (4) hypoplasia of the uterus; accompanied by insufficient and painful menstruation, (5) metrorrhagia of ovarian origin, and (6) sexual neuroses, such as masturbation, nymphomania, *etc.*

Herman¹⁴ is said to have been the first American surgeon to have performed this operation. Then a widespread application of this method was reported by many European surgeons. The same surgical procedure of resection of the presacral nerve has been employed by Learmonth and Braasch²¹ for cord, bladder, and certain painful vesical conditions. In 1933, Abbott and Pfaff² reported a case of bladder dysfunction and dysmenorrhea which responded to this operation. Since then Adson and Masson,⁴ Greenhill and Schmitz,¹³ Counseller and Craig,⁸ Abbott^{1, 3} White,²⁹ Wetherell,²⁸ DeCourcy,⁹ and Keene¹⁸ have recorded favorable results in cases of pelvic pain.

Anatomy and Physiology.—The inferior mesenteric plexus gives rise to the right and left mesenteric nerves which unite below the origin of the inferior mesenteric artery to form the presacral nerve (superior hypogastric plexus). The branches from the left side pass obliquely downward, while the branches from the right side pass posterior to the artery. There are many fine anastomoses between these nerves so that a true plexus is formed which is situated anterior to the bifurcation of the aorta and is separated from it by a thin layer of fascia. The plexus then follows the course of the sacrum into the pelvis. The parietal peritoneum and a thin layer of loose connective tissue lies anterior to the plexus. The root of the mesentery of the sigmoid colon is situated to the left. There are many variations of the superior hypogastric plexus but none of great importance. Latarjet and Bonnet gave it

the name of "presacral nerve." In about 20 per cent of the cases, the fibers join to form a new nerve, and in 80 per cent, the nerves are more or less spread out in plexus formation (Delmas and Laux¹⁰).

A few filaments from the superior hypogastric plexus course along the common iliac artery. The plexus itself continues down over the promontory of the sacrum and, at the level of the first sacral vertebra, divides into two distinct nerves; the inferior hypogastric nerves. These nerves course downward into the lateral rectal space and terminate in a mass of nerve fibers and ganglion cells named the hypogastric ganglion, which is situated on the superior pelvic space between the peritoneum and the fascia covering the levator ani muscles. This plexus forms again on the anterior surface of the rectum, just posterior to the uterus and vagina, and becomes intimately connected with the uterosacral ligaments.

The nerve supply of the ovary is derived chiefly from the ovarian plexus which arises from the aortic and renal plexuses and follows the course of the ovarian artery. Hovelacque¹⁶ states that three fibers arise from the middle of the renal plexus to join the ovarian plexus. Other nerve bundles may be traced directly to the ovarian ganglion which is situated near the origin of the ovarian artery. There are also rami which connect with the celiac and superior mesenteric ganglia. The ovarian plexus enters the suspensory ligament of the ovary and invests both the ovarian artery and vein. These fibers divide into branches supplying the fallopian tube and broad ligament, the hilus of the ovary and the lateral surface of the uterus. Kuntz¹⁹ states that the afferent fibers supplying the ovary are components of the tenth thoracic nerve.

The fallopian tube receives fibers from the uterine plexus, in addition to branches of the ovarian plexus. The afferent fibers supplying the fallopian tube, according to Kuntz, reach the spinal cord through the eleventh and twelfth thoracic and first lumbar nerves.

The nerve supply of the uterus includes both sympathetic and parasympathetic components. Fontaine and Herrmann¹¹ state that the nerve fibers in the wall of the uterus are derived from the great plexus of Frankenhäuser,¹² which is situated on each side of the body of the uterus and broad ligament. This plexus receives fibers from the hypogastric plexus, the lower lumbar and sacral sympathetic trunk and the second, third and fourth sacral nerves. There is no evidence to support the view that nerve fibers terminate in the uterine mucosa, as held by older investigators.

Cleland⁵ has demonstrated, by the use of paravertebral anesthesia, that the afferent fibers supplying the uterus enter the spinal cord solely through the roots of the eleventh and twelfth thoracic nerves.

In spite of the abundant nerve supply to the ovary, there is no conclusive evidence of a direct functional innervation either of the ovarian follicles or the interstitial tissue. Undoubtedly there are vasomotor changes in the ovary as a result of this complex nerve supply and yet Hinsey and Markee¹⁵ have

reported ovulation induced by the injection of pregnancy urine in rabbits in the complete absence of functional nerve fibers to the ovary.

Kuntz states that the sympathetic nerves supplying the uterus and fallopian tubes exert a motor influence and the parasympathetic nerves an inhibitory influence. However, certain experimental work has caused conflicting opinions to be held as there is evidence of uterine contractions occurring in the absence of nerve stimulations. Stimulation of the hypogastric nerves exerts a motor effect on the uterus and fallopian tubes, but the effect may be very slight. It is also conceded that afferent fibers from the uterus and fallopian tubes are carried through the hypogastric plexus. Thus the removal of the presacral fibers will relieve pain, but Adson and Masson feel that interruption of efferent fibers in the presacral group also produces a dilatation of the blood vessels in the genitalia and musculature of the uterus. This operation has had no deleterious effect upon subsequent pregnancy or the normal menstrual cycle and the functions of the bowel and bladder have not been impaired.

Mechanism of Dysmenorrhea.—Counsellor and Craig have described two types of dysmenorrhea: primary and secondary. The primary dysmenorrhea is not dependent upon pathologic change in the pelvis and many theories have been advanced regarding the cause of this painful phenomenon. The theory of retention of menstrual blood as a result of uterine displacement cannot be accepted readily because the cervix can be dilated with ease and Novak²⁵ has reported that the rate of discharge of menstrual blood of the normal woman averages about two-thirds of a drop per minute. This small amount of blood could hardly be retained by uterine displacement. The hypothesis of hypoplasia of the uterus causing pain as a result of faulty muscular development failing to respond to menstrual stimulation is not feasible because the majority of women have a uterus which is normal in size. There have not been sufficiently controlled reports to consider the endocrine system as a definite factor in the production of dysmenorrhea. It is also known that marriage and subsequent pregnancy will abolish certain types of dysmenorrhea; in addition, the psychic element must be borne in mind. However, there are certain cases in which menstrual pain is so severe that it resists any therapeutic agent and in this type of case resection of the presacral nerve is indicated.

The secondary dysmenorrhea is the result of demonstrable pathologic change in the pelvis, such as: uterine myoma, endometriosis, salpingitis, ovarian tumors and marked uterine displacement. It is obvious that correction of these known pathologic processes is indicated in preference to section of the presacral nerve. At times, the recognized pathologic process seems insufficient to cause such severe pain and, in these patients, presacral neurectomy may be utilized as an adjunct in the correction of severe dysmenorrhea.

Fontaine and Herrmann have described three types of cases in which resection of the presacral nerve afforded relief from pain in 22 of 28 cases.

(1) Where slight pathologic processes in the pelvis do not respond to ordinary gynecologic treatments. These periodic paroxysms of pain were described by Cotté as pelvic plexalgia. The distress begins in the region of

the uterus and radiates to the anus, coccyx and urinary bladder; pain may also radiate to the back and thighs.

(2) Where pain persists after correction of retroversion of the uterus or the removal of a sclerocystic ovary.

(3) Where the pathologic lesion is known but which has been found to be too extensive for surgical removal; inoperable neoplasms causing severe pain.

This report deals with types 1 and 2, or those cases relating to menstrual pain associated with little or no demonstrable pathologic process.

Operative Technic.—A low midline incision is made in the abdomen and the patient is placed in the Trendelenberg position. The intestines are packed away and a vertical incision is made in the posterior peritoneum from a point

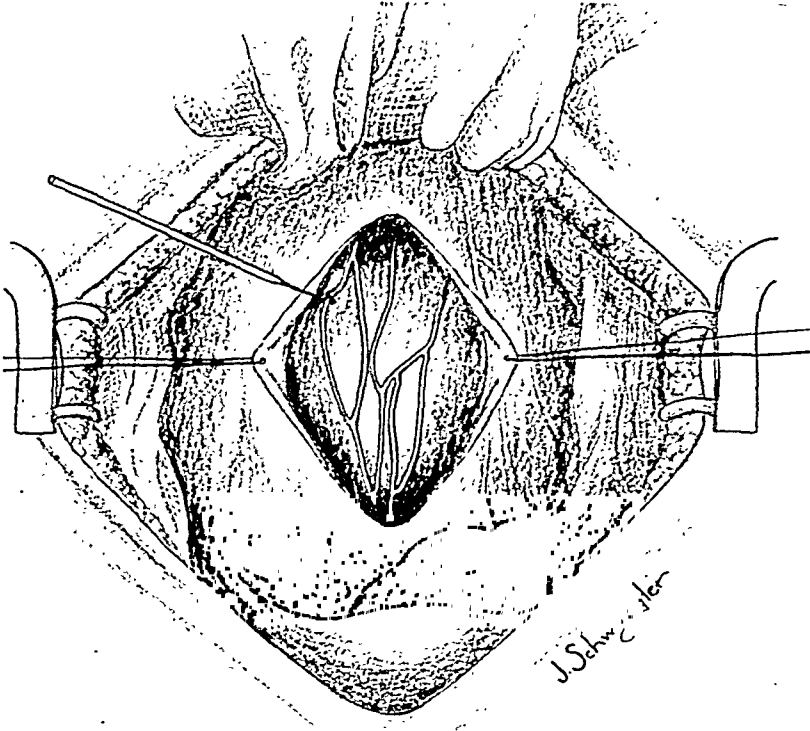


FIG. 1.—Illustrates incision in the posterior peritoneum with the edges retracted. The nerve fibers are picked up with a hook.

3 cm. above the bifurcation of the aorta to 6 cm. below it. The peritoneum is retracted with silk ligatures so that the superior hemorrhoidal artery is drawn out of the way on the left side. In a thin patient the nerves can be seen in a delicate plexus of pelvic lymphatics and loose connective tissue. The use of cotton pledgets will facilitate the dissection in the hollow of the sacrum, between the two common iliac arteries. Precautions must be taken not to injure the left common iliac vein, which lies on the medial side of the artery. Just beneath the aortic bifurcation the strands of the presacral nerve can be identified and picked up on a nerve hook. The application of silver clips will prevent troublesome oozing from the vasa nervorum. The dissection is then carried down over a distance of 6 cm. so that the hollow of the sacrum is denuded. The application of silver clips at the end of the pedicle will prevent

the seepage of lymph. The posterior peritoneum is sutured with fine catgut and the abdominal wall is closed in the usual manner.

CASE REPORTS

Case 1.—An unmarried woman, aged 20, complained of an inability to void or defecate unless massive doses of castor oil were taken. The bladder and bowel would empty every four days and this was accompanied by severe pain. This condition had persisted for two years and was also associated with a severe dysmenorrhea. The past history was negative except that the menses did not appear until she was eighteen and that for two years she suffered from blanching, discoloration and pain in both feet when exposed to the cold or emotional stress. Examinations were negative except for an atonic bladder and colon and the presence of Raynaud's disease of the lower extremi-

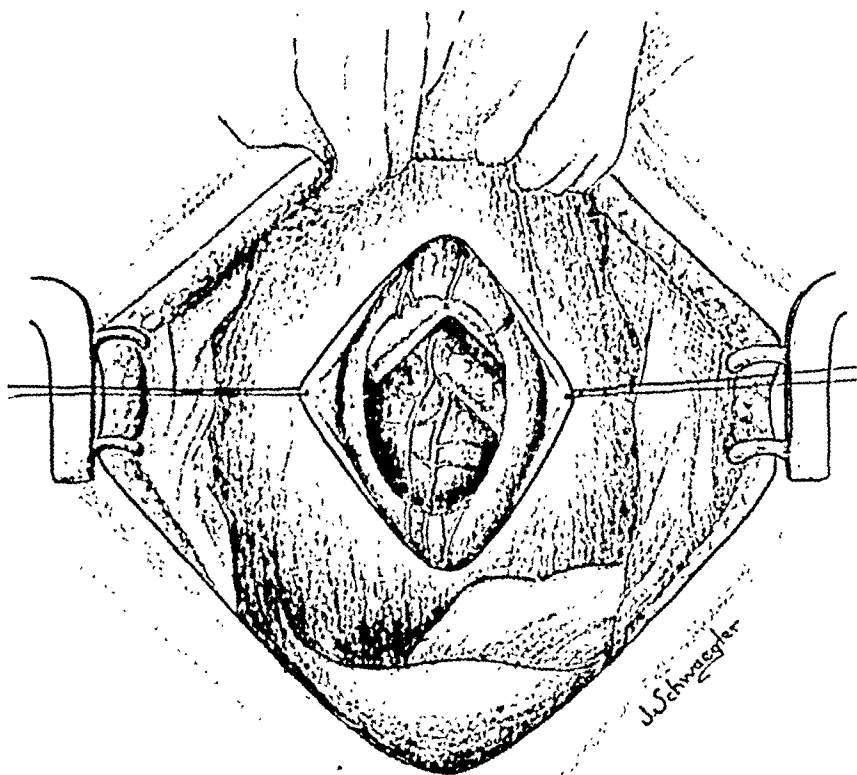


FIG. 2.—Operation completed revealing median sacral and iliac vessels above the promontory of the sacrum. Note silver clips on severed nerve fibers.

ties. The patient was not considered to be suffering from hysteria and the presence of Raynaud's disease seemed to indicate an imbalance of the autonomic nerves.

A laparotomy was performed October 21, 1932, under ether anesthesia and the pre-sacral nerve was resected. In addition, a bilateral lumbar sympathetic ganglionectomy was carried out. Immediately after operation, the lower extremities were warm, dry and pink. Four hours afterwards, the patient voided 150 cc. of urine without difficulty. It was necessary to administer enemata for seven days before a bowel movement occurred with the aid of mineral oil. However, the patient was able to void three and four times daily after the operation. On the fifth postoperative day, the menses appeared without distress. Since her discharge from the hospital, the patient has been able to void three or four times daily, and there has been a daily bowel movement. The feet have remained warm and pink and menstruation has been painless.

This case is illustrative of a general imbalance of the autonomic nervous system as no demonstrable pelvic pathologic process was found.

Case 2.—An unmarried woman, aged 20, had suffered from severe dysmenorrhea for years. Roentgen therapy and curettage had failed to afford relief. Examination was negative except for some tenderness over the sacro-iliac region. Roentgenograms revealed a developmental defect of the coccyx, but this was not considered to be an important factor. There was also a leukorrhea. On June 5, 1933, under ether anesthesia, a curettement was performed by Dr. B. C. Barnes and a small amount of reddish deciduous material was removed. A laparotomy was performed and the right ovary,

TABLE I
SUMMARY OF EIGHT CASES OF PRESACRAL NERVE RESECTION

Age of Patient	Type of Distress	Demonstrable Pathologic Change in Pelvis	Date of Operation	Results
(1) S. G., aged 20.	Dysmenorrhea. Inability to void or defecate	None	October 21, 1932	Free from pain
(2) F. H., aged 20.	Dysmenorrhea. Dull abdominal ache	Low grade endometritis. Cystic right ovary 5 x 2 x 1.5 cm.	June 5, 1933	Free from pain
(3) O. S., aged 28.	Dysmenorrhea. Constipation	Sigmoid colon adherent to left ovary. Small cyst of right ovary	July 25, 1933	Free from pain
(4) E. A., aged 27.	Dysmenorrhea. Dull abdominal ache	None	May 15, 1933	Free from pain
(5) G. C., aged 34.	Dysmenorrhea. Constipation	None	December 28, 1933	Free from pain
(6) V. W., aged 22.	Dysmenorrhea	None	September 19, 1934	Free from pain
(7) E. M., aged 20.	Dysmenorrhea	None	May 12, 1935	Free from pain
(8) C. W., aged 34.	Dysmenorrhea. Dull abdominal ache	None	June 13, 1935	Free from pain

which measured 5 x 2 x 1.5 cm., and contained a few cysts, was removed. It was felt that there was insufficient pathologic change to cause such pain, so the presacral nerve was resected. The patient made an uneventful recovery and she has been free from any menstrual or abdominal pain since the operation. The sacro-iliac distress was markedly relieved by a sacro-iliac belt.

Although there were some organic changes, it was felt that resection of the presacral nerve was of distinct benefit.

Case 3.—An unmarried woman, aged 27, had suffered from severe dysmenorrhea since puberty, but for a year the pain had become so severe that she was incapacitated for seven to ten days each month; in addition, she had noted a constant dull ache in the lower abdomen. Examinations were negative except for tenderness in both lower quadrants of the abdomen. On May 15, 1934, under Avertin anesthesia, laparotomy was

performed and the pelvic organs were found to be normal in size, position and appearance. The presacral nerve was resected and recovery was uneventful. Menstruation has been painless and the dull ache in the abdomen has disappeared since the operation.

Case 4.—An unmarried woman, aged 34, complained of a dull ache in the pelvis and severe dysmenorrhea to the extent that her family physician had administered as much as three-fourths grain of morphine to give relief. Seven years previously she had undergone a cholecystectomy and a year before a right cystic ovary was removed. Examinations were negative. On June 12, 1935, under avertin anesthesia, a laparotomy was performed. There were no demonstrable pathologic changes in the pelvis and a presacral neurectomy was carried out. Recovery was uneventful and the patient has remained free from menstrual pain.

The last two cases are typical of severe dysmenorrhea with pelvic plexalgia.

CONCLUSIONS

Eight cases of dysmenorrhea, in which there was little or no pathologic change in the pelvis, were relieved by resection of the presacral nerve. This group of patients is too small to warrant general conclusions, but the results obtained seem to justify the employment of this procedure for patients suffering from severe dysmenorrhea which fails to respond to the ordinary methods of treatment.

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EXPERIMENTAL PRODUCTION OF CHYLOTHORAX BY OCCLUSION OF THE SUPERIOR VENA CAVA*

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IN THE course of some experiments on dogs in which attempts were being made to produce the condition known as traumatic asphyxia, the superior vena cava was ligated. Much to our surprise, the immediate effect of the occlusion was almost negligible. The first of our animals, in which the superior cava was ligated, became short of breath 12 days following the operation and died on the following day. Autopsy revealed the presence of 900 cc. of milky fluid in the pleural and pericardial cavities.

As a result of this observation, further studies have been carried out. The findings dealing in particular with the incidence of chylothorax following occlusion of the superior cava are detailed. Other studies concerning the cytology and chemistry of the fluid will be reported later.

METHOD.—Dogs were used as the experimental animals in some instances and cats in others. Under ether or nembutal anesthesia and using positive pressure through an intratracheal catheter, the right side of the chest was opened through an intercostal incision. The superior vena cava was carefully separated from the surrounding structures and it was doubly ligated with silk just distal to the entrance of the azygos vein. The incision in the chest was closed.

The chest was aspirated from time to time in order to obtain fluid for study and for the purpose of relieving dyspnea. In some instances the animals were allowed to die, while in others they were sacrificed.

Venous pressure determinations were carried out in most of the studies on dogs both before and at various intervals following the operations. The veins used were the external jugular and femoral. The method employed was that in which salt solution is allowed to flow into the vein from a burette until the level of the venous pressure is reached.

In four experiments, occlusion of the superior cava was preceded by ligation of the thoracic duct.

RESULTS.—The superior cava was ligated in 13 dogs. Bloody fluid was aspirated from the chest of most of these several days following the operation. Chyle was obtained later from the pleural cavities on aspiration in seven of the

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13 animals. The length of time separating the operation and the appearance of the chyle, the duration of the chylothorax and the quantity of chyle were variable factors in the different experiments.

The interval of time separating the operation and the obtaining of chyle on aspiration varied from nine to 25 days in the seven experiments, the average time being 17 days. These figures are not absolute as chyle may have been present but not detected on aspiration. The fluid reaccumulated rapidly in some animals and slowly in others. Two of the animals died 13 and 18 days following the occlusion of the superior cava and 900 and 1,100 cc. of chyle were present in the pleural cavities. A small quantity was found in the pericardial cavity. Death was due almost certainly to the reduction in vital capacity resulting from the collapse of the lungs by the fluid. One animal which had had chyle in the pleural cavity previously had only bloody fluid at the time of death. Two animals were killed 15 and 27 days following the operation and 935 and 700 cc. of chyle were present in the pleural cavities. In the remaining two dogs of this series, chyle ceased to accumulate in the pleural cavities 34 and 44 days following the operations and the experiments were terminated.

The venous pressure as measured in the external jugular vein rose immediately in all experiments following the occlusion of the superior cava. From a level of slightly less than zero, the pressure rose approximately 200 Mm. H_2O . There was a gradual decline from this point as the venous collaterals increased in size, but usually the pressure did not return entirely to the pre-operative level. The height to which the venous pressure rose following the operation did not seem to determine whether or not a chylothorax ensued. The venous pressure readings as determined in the external jugular vein at the time that the first chyle was aspirated in the seven experiments were 190, 140, 145, 135, 100, 75 and 30 Mm. H_2O . It is to be noted that the venous pressure was 100 or greater in most of the experiments but it is of interest that chyle appeared in one instance in which there was little elevation in the pressure. In this latter study, the venous pressure was 175 Mm. H_2O on the day following the occlusion of the superior cava. Four days later, the pressure had declined to 60 Mm. H_2O and blood-tinged fluid was aspirated from the chest. Six days subsequently, the jugular pressure was 20 Mm. H_2O and blood-tinged fluid was obtained from the chest. Chyle was aspirated from the chest 13 days later and the venous pressure was 30 Mm. H_2O . The animal was killed two days subsequently and 700 cc. of chyle were found in the pleural and peritoneal cavities. The thoracic duct and azygos vein were patent at autopsy. There was less distention of the lymphatics of the mesentery of the intestines in this experiment than in most of the others in which chylothorax was present. The mediastinal tissues in this and other experiments were markedly edematous and an incision into them resulted in the escape of a considerable amount of milky fluid. The mediastinal lymph nodes were greatly enlarged and filled with chyle. There was no evidence of previous injury to

the pleura or other structures. The findings indicated that the chyle entered the pleural cavity through an uninjured pleural layer.

In some instances in which the mesenteric lymphatics were injected with Berlin-blue, the material did not pass beyond the regional lymph nodes where diffuse rupture took place. The force required for the injection indicated an increase in the intralymphatic pressure. There was marked edema of the neck, chest and anterior extremities in two of the experiments.

As has been stated, occlusion of the superior cava was preceded by ligation of the thoracic duct in experiments on four dogs. The method which was used for the occlusion of the thoracic duct was that described by Lee¹ in which the duct, together with the covering of the thoracic aorta, and the azygos vein are included in the ligature. It was performed at approximately the level of the seventh thoracic vertebra. No fluid was obtained on aspiration of the chest following this procedure. After an interval of seven to 13 days, the superior cava was doubly ligated. Chylothorax did not result in any of these studies, and no more than 15 cc. of blood-tinged fluid were obtainable on aspiration on any one occasion.

Twenty-three experiments were performed upon cats, in whom the superior vena cava was ligated. Chylothorax was produced in 14 of these. The length of time separating the operation and the obtaining of chyle on aspiration varied from four to 49 days, the average time being 22 days. However, in the two experiments in which the interval was 49 days, aspiration had not been attempted during the preceding 34 days. Several of the cats died as a result of the accumulation of large quantities of chyle in the pleural cavities. More frequent aspirations would probably have prevented the death of these animals. In other instances, repeated aspirations were followed by the disappearance of the chylothorax. In still other experiments, the animals were killed before the accumulation of chyle had ceased. The details of an experiment in which rather large quantities of chyle were aspirated from time to time are given below.

TABLE I
FAT CONTENT IN CHEST FLUIDS (CAT. NO. 20)

Date	Quantity Fluid cc.	Gm. Fat per 100 Gm. Fluid	Date	Quantity Fluid cc.	Gm. Fat per 100 Gm. Fluid
July 18	40	0.58	Aug. 16	105	3.33
July 22	20		Aug. 20	25	1.68
July 29	30	1.69	Aug. 24	170	2.58
Aug. 3	140	2.02	Aug. 26	150	2.04
Aug. 6	50		Aug. 30	105	0.79
Aug. 10	125	3.66	Sept. 2	35	3.09
Aug. 13	112	3.88	Sept. 6	185	2.50*

* Postmortem.

Cat No. 20, weight 2.6 Kg. The superior vena cava was doubly ligated June 28, 1935. Aspiration of the chest was negative for fluid July 5 and 8, 1935, but 6 cc. of blood-tinged fluid were aspirated July 12, 1935. The first chyle was obtained four days later, July 16. On subsequent days the amounts shown in Table I were secured. The cat died September 6. There were 185 cc. of chyle in the two pleural cavities and a small quantity in the pericardium. Many small lymph vessels were visible in the neighborhood of the intercostal vessels. There was no free chyle in the peritoneal cavity. The lymphatic vessels in the mesentery of the intestine were distended with chyle. No evidence of infection was found. There had been very little loss in weight. The mechanical effects of the presence of the fluid probably caused the death of this animal.

The following chemical studies were made on fluids from this animal. Total fat determinations by the ether extraction method were made (Table I).

On three fluids the lipid partition was determined according to the method of Kirk, Page and Van Slyke¹ (Table II).

TABLE II
LIPID DISTRIBUTION IN CHEST FLUIDS (CAT. NO. 20)

Date	Total Lipid C	Total Lipid P	Total Lipid N	Total Choles- terol	Free Choles- terol	Bound Choles- terol	Choles- terol Esters Calc.	Phos- phatides Calc.	Neutral Fats Calc.	Total Lipids Calc.	Total Lipids 1.3 X Lipid C
July 18	505.2		3.5	130.1	72.8	57.3	96.9				656.8
July 29	1874.6	13.1	6.9	84.6	63.3	21.3	36.0	308.7	2097.8	2505.8	2437.0
Sept. 6	2521.4	10.9	8.3	111.3	66.5	44.8	75.7	257.8	2948.4	3348.9	3277.8

In spite of the quantity of phosphatide present, the high cholesterol and total fat contents of these fluids place them definitely in the group of true chylous fluids, as distinguished from pseudochylous fluids by Wallis and Schölberg.² According to these authors, chylous fluids contain cholesterol, little or no lecithin and have a fat content of 0.4 to 40 per cent. Pseudochylous fluids, on the other hand, are rich in lecithin but contain little or no cholesterol.

The relation between these fluids and blood and lymph will be discussed in a later paper.

The chest fluids found in these animals have been studied for their cellular content by the supravital method. Table III gives the cellular picture as found in a typical animal (Cat. No. 20).

Discussion.—Carlson³ reported recently his experimental studies on the effects of occlusion of the superior cava. He found that dogs tolerate obstruction of the superior cava above the level of the azygos vein but not obstruction including the azygos when it is produced in one stage. A rise in venous pressure was noted and the development of collateral venous pressure was studied. The development of chylothorax was not observed by Carlson in the seven experiments which he performed. He stated: "Except in two dogs that died of empyema, pleural effusions did not develop in the dogs in which obstruction above the azygos vein had been carried out. In the only dog that was subjected to preliminary obstruction of the azygos vein a sanguinous effusion developed, from which he recovered within two weeks."

TABLE III

TOTAL AND SUPRAVITAL CELL COUNTS IN CHEST FLUIDS (CAT. NO. 20)

Date	Quantity Fluid cc.	Total W.B.C.	White Blood Cell Differential					
			P.M.N.	P.M.E.	Lymph- ocytes	Mono- cytes	Clasma- tocytes	Serosal Cells
July 12		5,600	2,688	168	2,464	280	..	..
July 16		20,000	2,300	400	16,800	500	..	..
July 18	40	12,800	1,984	192	9,472	512	640	..
July 22	20*							
July 29	30	10,000	3,500	500	5,800	100	100	..
Aug. 3	140	6,800	1,632	...	4,420	544	204	..
Aug. 6	50	10,400	5,720	312	3,640	624	104	..
Aug. 10	125*							
Aug. 13	112	16,400	12,300	328	2,952	328	164	328
Aug. 16	105	7,200	2,916	72	3,456	648	36	72
Aug. 20	25	10,720	5,038	642	5,038	...	..	..
Aug. 24	170	5,520	3,202	...	2,153	...	165	..
Aug. 26	150	9,920	4,364	99	4,464	594	396	..
Aug. 30	105	12,000	4,200	180	7,500	120	..	..
Sept. 2	35	9,840	7,970	...	1,870	...	..	..
Average		10,554	4,447	223	5,387	327	139	31

* No cell counts made on these fluids.

It is of interest to speculate as to the manner in which occlusion of the superior cava results in chylothorax and chylopericardium. It is well known that occlusion of the left thoracic duct does not result in this condition. We have observed recently that ligation of the right and left thoracic ducts does not cause chylothorax. The fact that occlusion of the superior cava results in the accumulation of chyle in the chest, while occlusion of the main right and left ducts does not, indicates that there are a number of other lymph vessels which empty into the superior cava or its branches. This would be anticipated from work of Lee,⁴ who found lymph vessels which entered the intercostal veins. These veins, however, empty into the azygos which was not occluded in our experiments. Lee occluded the thoracic duct by an intra-thoracic method and his findings as regards the collateral circulation are as follows: "As a result of these dissections, two general types of collateral circulation were established. The one type consisted of a collateral circulation to the right thoracic duct, the other type comprised those cases in which the lymph entered the azygos vein or its branches."

It is likely that there are lymphaticovenous communications in the peritoneal cavity. This was suggested by Lee. If so, these would be expected to dilate in the presence of superior caval obstruction. It would seem that obstruction to the flow of lymph would be most marked immediately following the occlusion of the superior cava. However, the fact that chyle does

not appear in the thorax for a number of days does not support this viewpoint, although it does not disprove it.

We are unable to state from the present experiments what part, if any, the venous blockage per se played in the production of chylothorax. One is unable to occlude the superior cava without causing some interference with the flow of lymph. Experiments are now being carried out in which attempts are being made to produce lymphatic obstruction without venous ligation.

SUMMARY

In experiments on dogs and cats in which the superior vena cava was ligated, approximately one-half of the animals developed chylothorax, and chylopericardium was present in some of these.

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ACUTE SUPPURATIVE PERICARDITIS

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ACUTE suppurative pericarditis has been recognized clinically since the early days of medicine. "Galen noted it in animals and characteristically made the bold deduction that man could likewise suffer from the disease." Riolan, in 1649, advocated pericardiotomy for the relief of pericardial effusion. In the last century Laennec, Corvisart, and Auenbrugger drew attention to the physical signs of the disease. Indeed, the former advised Riolan's plan of trephining the sternum. Romero, in 1819, was the first to perform a successful pericardiotomy.¹

In the last 40 years the surgical treatment of pericarditis has received much attention in surgical literature. Still, in 1933, Truesdale¹⁴ was able to collect only 152 reported cases treated by pericardiotomy. He emphasized the steady improvement in the mortality from 65 per cent in the 52 cases reported by Porter and Roberts⁹ in 1900 to 42 per cent for the entire series of 152 cases.

While suppurative pericarditis is not a clinical rarity, the paucity of reported cases clearly indicates that the profession at large is not aware of the advances in therapy which have occurred, and most of the sufferers from the disease are not given the benefit of surgical treatment.

Suppurative pericarditis is as much a surgical disease as empyema. As in empyema, there is a closed collection of pus, with the danger of toxemia and septicemia. In addition, the mechanical pressure on the heart, already weakened by the disease, is a more serious factor than the mechanical pressure in empyema.

We are presenting a case of acute suppurative pericarditis in an infant successfully treated by pericardiotomy, which happens to be the youngest among the survivors (Fig. 1). The procedure used failed to permit satisfactory exploration of the pericardium. As the Rhodes¹⁰ operation has been frequently criticized from this standpoint and for allowing pocketing posteriorly, and as some hazardous procedures have been advocated to overcome its shortcomings, it has seemed worth while to call attention, briefly, to Allingham's² operation which has received scant notice in most discussions on technic, although we have had no opportunity to put it to the test.

Case Report.— T. H. aged 18 mos. Admitted to St. Mary's Hospital for Children June 5, 1933. C. C. Cough. P. I. Had measles in March followed by pneumonia. Was admitted to Bellevue Hospital from which he had been discharged three weeks previously. Since then has had continuous cough, with recurrence of fever, dyspnea, loss of appetite, and malaise. P. H. Pneumonia of left lung at 6 mos. Treated at St. Mary's Hospital. P. X. T. 103.6°, P. 160, R. 80. Breathing suppressed over right

lung with many crackling râles over lower part of right lung and in axillary line. P. D. Bronchopneumonia of right lung. Roentgenogram shows pathology involving lower two-thirds of the right lung (Fig. 2). 6/9/33 W.B.C. 18650, P. 78, L. 22.

Course.—6/23 Exploratory thoracentesis, no fluid. Generally improved. 7/8 Meningitic symptoms. Spinal puncture. Clear fluid, three cells, no organisms. 7/10 Signs of pericardial effusion. Cardiac dullness markedly increased. Apex beat diffuse in anterior axillary line and in third, fourth and fifth interspaces. Sounds of fair quality. Slight precordial bulge. No murmurs or friction rub. Dullness and bronchial breathing in left lower posterior chest.



FIG. 1.—Photograph of patient one year after pericardiotomy.

Roentgenologic Examination.—Cardiac shadow is roughly oval in shape, greatly enlarged and indicates the presence of a pericardial effusion (Fig. 3).

Pericardiocentesis in fourth interspace to left of sternum. 18 cc. cloudy, lemon-yellow fluid removed. 11,600 cells. Culture, pneumococcus type iv.

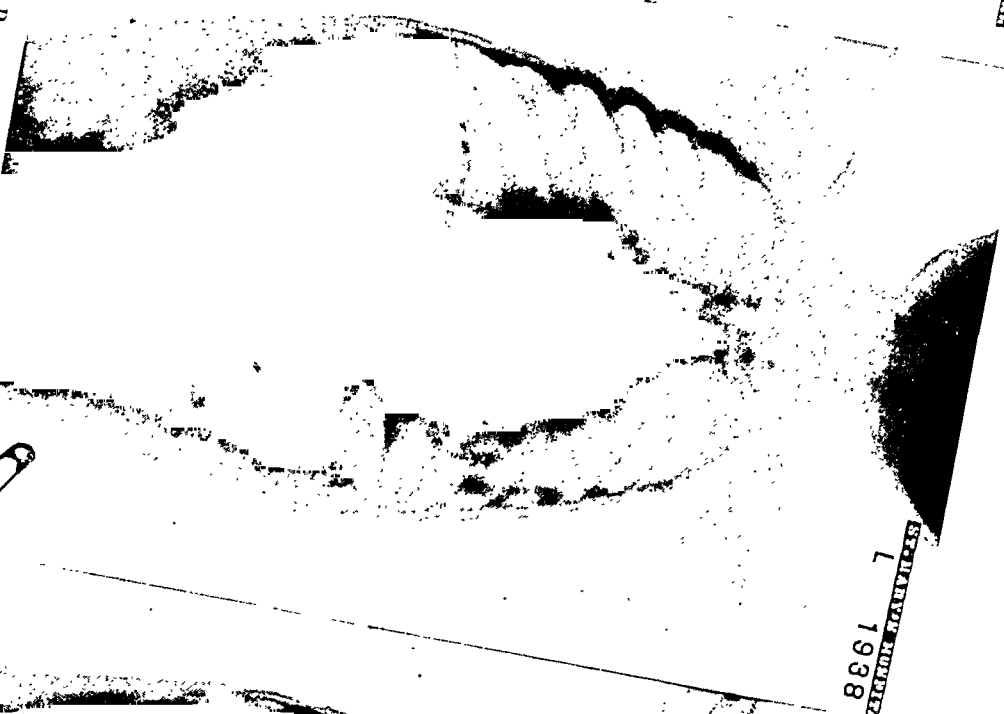
Operation.—Local anesthesia, hockey-stick incision over sternum from second to fifth costal cartilage. Lateral extension over left fifth costal cartilage. Fifth costal cartilage excised and fourth and third divided at sternum. Flap raised. Subcostal muscles incised and internal mammary artery exposed and retracted medially. Pericardium exposed and pleura separated to left. Pericardium appeared opaque and thick. Divided vertically between stay sutures. Several ounces of cloudy fluid evacuated. Incision too high to permit exploration beneath or behind the heart. Heart and pericardium covered with fibrin one-quarter inch thick. The heart lay anterior, presenting at the opening in the pericardium. Soft rubber catheter inserted over left ventricle and sutured to chest wall. Wound partially closed about drain. Immediately after operation pulse dropped to 120 and quality distinctly improved. Culture—pneumococcus.

ALVA HOSPITAL
1910



2.—Roentgenogram, June 5, 1933, showing pneumonia involving the right middle and lower lobes.

SEWARD HOSPITAL
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3.—Roentgenogram, July 1, 1933, showing pericarditis with effusion.

ALVA HOSPITAL
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Fig. 4.—Roentgenogram, September 26, 1933, after drainage of the pericardium.

7/14 Rubber tube removed. Temperature normal on twelfth day and remained normal for two weeks. 7/28 Abscess right thigh opened. Culture pneumococcus. Wound of chest completely healed in six weeks. Convalescence slow with frequent setbacks and continuation of cough, rapid pulse and dyspnea. 9/26 Discharged (Fig. 4).

Diagnosis.—The diagnosis is not always evident, as is shown by the legion of physical signs which have been described as characteristic of pericardial effusion. The increased area of cardiac dullness, precordial bulging, diffuse and wavy apex beat, area of dullness and bronchial breathing in left lower chest posteriorly, are most commonly found. These signs accompanied by dyspnea, orthopnea, septic temperature, weak, rapid pulse, cyanosis and leukocytosis, should suggest the diagnosis.

Fluoroscopic Findings.—We also wish to call attention to the fluoroscopic findings which are believed to indicate the presence of fluid in the pericardium. If further investigation confirms these findings, they will be of considerable value in differential diagnosis.

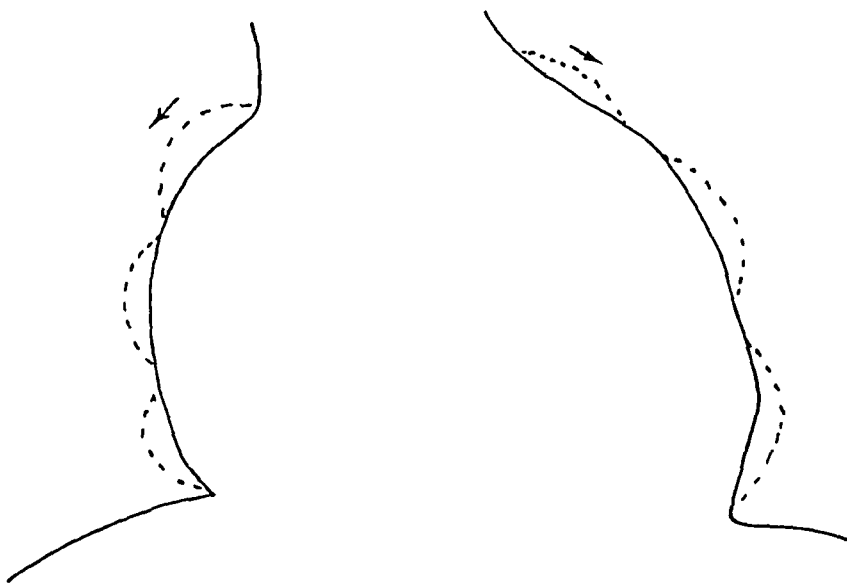


FIG. 5.—Schematic drawing of pericardium as seen under fluoroscope. Dotted lines represent fluid waves set up by contractions of the heart. These arise and are most marked near the base and descend to the diaphragm along the lateral margins. They seem to occur at systole and immediately after.

In pericardial effusion the heart shadow is much enlarged and globular in shape. At first glance there appear to be no contractions. On closer scrutiny slight systolic contractions can be seen at systole, but the excursion is markedly decreased. Small fluid waves were seen following systole, which arose at the base and passed down the upper left margin toward the apex, and down the right border toward the diaphragm (Fig. 5). These fluid waves, we believe, are pathognomonic of fluid in the pericardium.

As far as we know, such waves have not been described. Theoretically, such a phenomenon would appear logical. Fluid is present about the heart in a closed cavity with elastic walls. As the heart suddenly contracts at systole, the tension within the pericardium is lessened, and a disturbance of

the fluid is set up, causing fluid waves which subside as the tension is more gradually increased during systole.

We have had, as yet, only one other opportunity to check these findings. That was in a case of pericardial effusion, confirmed by physical signs and repeated roentgenograms only. The same phenomena were observed.

Obviously further confirmation of these findings is necessary to establish them as a *sine qua non* of fluid in the pericardium. The observation is offered with the hope that interest may be aroused in fluoroscopy of pericardial effusion and its value established. If fluid waves are always present, this sign would be of great value in eliminating enlargement of the heart from other causes.

Operative Technic.—The operation which is most popular was first described by Rhodes.¹⁰ It consists of a hockey-stick incision down the left side of the sternum with a lateral extension over the fifth or sixth costal cartilage. The fifth or sixth cartilage is excised and as many more may be divided as is necessary for a full exposure. The pericardium is exposed and the pleura, if present, gently pushed to the left by blunt dissection. The pericardium is opened vertically and thoroughly explored with the finger to separate any adhesions and open any pockets. Local anesthesia is preferable.

At operation, it was evident that in the dorsal position the heart tended to obstruct drainage. It was felt that this was partially due to its floating upward on the fluid, and that this tendency would be combatted by the prone position, as well as permitting dependent drainage for the fluid behind the heart. Drainage seemed to be facilitated by this procedure.

An adhesive pericarditis might be expected as a sequela, although in younger patients it would not be so likely as in adults. In our case there was no evidence of impairment of the heart, the only abnormality being the weakness of the thoracic wall, due to failure of the costal cartilages to reunite. So far as we are aware, there have been no instances of serious cardiac impairment among the survivors. Shipley¹² writes, "Of the six patients upon whom I have operated for pyopericardium and who recovered, I have kept track of five and no one of the five is disabled." Williamson,¹⁷ in commenting on his case reports, "There is today no evidence of a heart crippled by adhesions to surrounding pericardium."

The best operative approach to the pericardium in suppurative pericarditis is still a debatable question and merits consideration. There is a definite objection to anterior median drainage. The anterior position of the heart in the pericardium tends to obstruct the drainage tract and allow pocketing, especially posteriorly. This may be partially overcome by creating a fairly large defect in the pericardium, postural drainage (*i.e.*, prone position) as suggested by Peterson,⁷ by the use of drainage beneath the heart, and by flushing the pericardium with fluids as advocated by Pool.⁸ In Truesdale's¹⁴ case the Rhodes' technic failed to obtain satisfactory drainage. The difficulty

was overcome in the second, and successful, case by a second horizontal incision in the seventh interspace from the nipple line to the posterior axillary line, with resection of two inches of the seventh and eighth ribs. Fortunately, the pericardium was in contact with, and adherent to, the pleura, as well as adherent to the visceral pleura of the lung, so that it was possible to open the pericardium beyond the apex of the heart without opening into the free pleural cavity. Through-and-through irrigations were employed for a few days and the patient went on to a complete recovery.

"In Loucks' successful case the anterior incision failed to promote recovery and he resorted to posterior drainage of the pericardium through a thoracotomy wound which had been made for empyema. . . . In commenting upon his experience the author states that the posterior drainage has certain natural advantages. It is the method of choice only in cases in which, because of an existing pleuritis or empyema, there is reasonable evidence that the main pleural cavity has been sealed off from the operative field" (Truesdale¹⁴).

The second case quoted by Loucks⁶ was operated upon by Heuer. The usual anterior incision was made but the two layers of the pericardium were adherent and the fluid could not be evacuated. An incision was made through the posterior axillary line. The lung was adherent to the parietal pleura and compressed by the pericardial fluid. An incision was made deliberately through the lung and temporary improvement was obtained. The pericarditis was secondary to an actinomycosis of the spine and the patient died subsequently.

Transpleural drainage according to Loucks was employed successfully in a case by Stewart and Garrod. They had resected the left eighth rib in the scapular line for empyema. Three weeks later they incised a bulging pericardium through the same incision. West recorded a similar successful case, and Libby a case that died. Brinton and Collins reported an operation upon a case of suppurative pericarditis in which they incised through the fifth interspace in the anterior axillary line, supposing it to be an empyema, which resulted in a collapse of the lung and a mortality a few hours later.⁶

Obviously Truesdale's and Loucks' solution, for lateral or posterior drainage, is applicable only under certain specific, favorable conditions and in the ordinary case is fraught with great danger of collapse of the lung and soiling of the pleural cavity.

Allingham,² following an unsuccessful drainage by removal of two inches of the fifth costal cartilage, devised an ingenious operation upon cadavers, which was successfully employed three decades later by Thomas¹³ in a case of pericarditis secondary to an acute osteomyelitis of the femur.

Briefly, he advocated an upper left rectus incision and an extraperitoneal approach through the diaphragm and pericardium. He claims for this procedure safety from contamination or injury of the pleura, dependent drainage, and great ease for exploration of the heart to its extreme limits. It would also preserve the integrity of the thorax over the heart.

In our case the incision was too high to permit adequate exploration beneath the heart, and we were fortunate that pocketing did not occur. It would appear that excision of the sixth or even seventh costal cartilage would facilitate exploration. Shipley's^{11, 12} combined transsternal and transchondral approach is an excellent method for the attainment of these ends. He makes a trephine opening in the sternum adjacent to the attachment of the fifth, sixth, and seventh costal cartilages. The ends of as many cartilages as desired may be cut away permitting good exposure and a well placed approach.

Allingham's epigastric incision seems to merit further trial. Its advantages have been adequately described and resulted, in Thomas' hands, in a cure of one of the few survivors, in whom osteomyelitis was the etiologic focus. It also does not result in a permanent weakness of the thoracic wall.

SUMMARY AND CONCLUSIONS

(1) Truesdale collected 152 cases of suppurative pericarditis treated by pericardiectomy with a 42 per cent mortality.

(2) Incision should be low and the pericardium adequately opened.

(3) Allingham's epigastric incision has been neglected and appears to merit further trial.

(4) The case cited is the next to the youngest reported, and the youngest of the survivors.

(5) Pick's disease is not to be anticipated as a sequela of surgical drainage of the pericardium.

I wish to express my appreciation to Dr. Dever S. Byard, Dr. Charles E. Farr and Dr. Edward D. Truesdell for permission to report this case.

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GASTRODUODENAL SURGERY

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THE following remarks are based on observations made at various clinics on the mainland and in Europe, from current literature, and from personal experience during the past 12 years with 188 operative procedures for gastroduodenal lesions.

Perhaps no other surgical problem of the abdomen has been so widely discussed within recent years, in an attempt to rationalize its treatment, as has that of duodenal ulcer. Many of the problems have been clarified, many yet await solution. It has been the experience in the past that until the etiology of a disease was known its complete control or even logical treatment was not accomplished. Until we know in a more exact manner the exciting causes of ulcers, why certain individuals have a so called ulcer diathesis, why the symptoms are intermittent in nature, why gastric ulcers are prone to undergo malignant degeneration and duodenal ulcers very rarely do, and the why and wherefore of many other phases of this common malady, we will continue to grope about in the fog of uncertainty, adopting that scheme of therapy which is receiving the popular acclaim at the moment.

In attempting to evaluate the relative merits of medical versus surgical treatment, it is at once apparent that the internist cannot be certain in a relatively high percentage of cases whether the condition which he is treating for ulcer is actually that or some other pathologic condition simulating ulcer. Again the life cycle of ulcer symptoms is one of recrudescence and the impression may be gained that a cure has been effected when in reality symptoms are but quiescent. On the other hand, end-results following surgery are difficult to obtain. Many of the complications may be years in developing, an accurate follow up is laborious, frequently inaccurate, and the human equation when stimulated by an undue amount of enthusiasm may be hard to evaluate.

However, one may safely say that unless an emergency exists, such as perforation or at times hemorrhage, operative interference in cases of duodenal ulcer is to be considered only when medical treatment has been conceded to be a failure. Our experience has been that the success of medical treatment depends to the greatest extent on the financial status of the patient plus his willingness to cooperate with his medical attendant. In the laborer whose daily toil furnishes the only means of sustenance for himself and family, whose dietetic regimen cannot be supervised and whose periods of rest and recreation are practically nil, the outlook for nonoperative cure is small in comparison to the individual who has everything at his command and is willing to avail himself of his opportunities for recovery.

Gastric ulcers, on the other hand, are to be viewed with suspicion from the beginning due to their potential possibilities of being or of becoming malignant. If not responding readily to a medical regimen they are candidates for surgery and here more radical surgery is generally recommended than when dealing with a duodenal ulcer.

Surgery of carcinoma of the stomach, with few exceptions, is even more disappointing than that for most organs whose complete extirpation is compatible with life. The lesion is usually so far advanced before being diagnosed that radical removal if at all feasible offers little hope for permanent cure. With few exceptions palliative measures are scarcely worth the effort expended by the surgeon, which is negligible compared to the mental and physical anguish experienced by the patient. If his life is prolonged it is usually, as someone has said, to the end that he may suffer more. The one redeeming feature and the one that usually justifies exploration is the fact that what appears to be a malignancy at times proves to be an inflammatory process. Until such time when our diagnostic procedures enable us to bring the patient with carcinoma of the stomach to the surgeon in its early localized state, the results from surgery will continue to offer little that will alleviate his plight and practically nothing toward his permanent cure.

When for various accepted reasons the patient with a duodenal ulcer is subjected to operation, we have for consideration a number of procedures that have given more or less satisfactory results in the majority of people's experience. Under this heading may be mentioned the various pyloroplasties, gastroduodenostomy, gastro-enterostomy with or without a direct attack on the ulcer, subtotal gastric resection and pyloric exclusion.

The first of these, pyloroplasty, when applicable, is the most conservative of all the procedures and has the distinct advantage in that the gastric content continues to empty into the duodenum where it is least likely to give rise to a marginal ulcer. It has been shown both clinically and experimentally that the incidence of marginal ulcer develops in direct proportion to the nearness with which the anastomosis between stomach and small intestine approaches the ileocecal valve. When the ulcer lies on the anterior or superior portion of the duodenum it may at times be easily excised and the incision prolonged across the pylorus into the stomach and converted into a pyloroplasty by approximation of its extremities. By this simple procedure the ulcer is removed, the sphincter action of the pyloric muscle abolished, temporarily at least, the outlet of the stomach enlarged to allow quicker emptying time, and regurgitation of alkaline duodenal contents into the stomach to neutralize gastric acidity is brought about. Unfortunately, in many cases due to the inflammatory reaction about the ulcer or to the anatomic construction of the duodenum, pyloroplasty is not mechanically feasible. The descending portion of the duodenum may then be found mobile or capable of being mobilized by freeing it of its lateral peritoneal attachment permitting of gastroduodenostomy, anastomosing the duodenum along the

greater curvature of the stomach in the region of the pylorus. Needless to say, it is essential here as elsewhere in gastro-intestinal work to make the anastomosis without tension.

On a recent visit to Professor Wilkie's Clinic in Edinburgh this method of short circuiting the gastric outflow below the sight of the ulcer was demonstrated on several occasions, and the value of this method emphasized. The operator had used this method for many years and was pleased with the results, finding it especially valuable and preferable to gastro-enterostomy in those cases where there was a high gastric acidity.

With the lapse of time allowing for longer and more accurate observation of end-results the high esteem in which posterior gastro-enterostomy was held in the treatment of duodenal ulcers would appear to be definitely on the wane. Hinton and Church,¹ in a recent article on observations made in the follow up clinic in Bellevue Hospital, found an incidence of 16.4

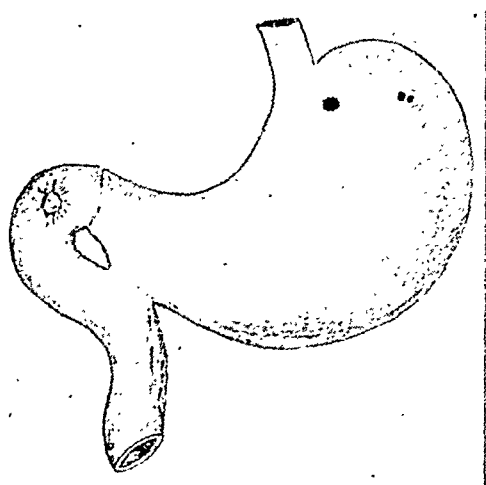


FIG. 1.—Gastroduodenostomy for duodenal ulcer.

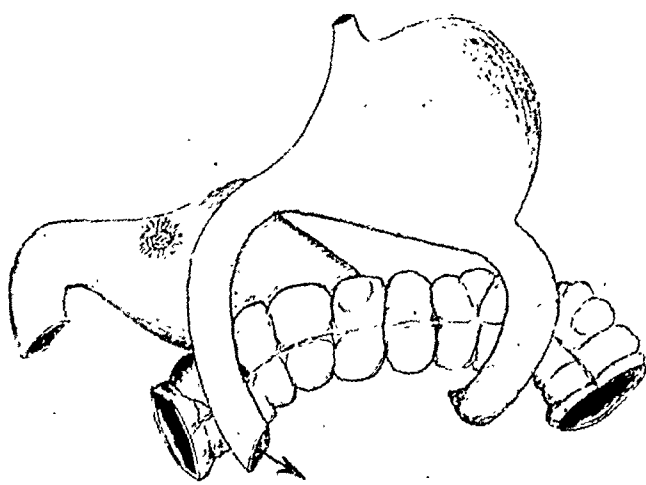


FIG. 2.—Showing a method of pyloric exclusion for gastric ulcer.

per cent of marginal ulcers following gastro-enterostomy. In 79 cases, the greater majority of which had been followed for less than five years, there were 13 gastrojejunal ulcers, three occurring after seven years. They emphasize the necessity of a ten year follow up in determining end-results. Lewisohn and Berg² have for a number of years insisted on the high incidence of marginal ulcer following this operation and reported an incidence of about double that of Hinton. Our experience with increasing data has been that the operation is one that has limited value. Too frequently the patient after a period of freedom from symptoms presents himself later because of epigastric pain, distress, or hemorrhage, and the symptoms are found to be due either to a new duodenal ulcer, reactivation of the old one, or a marginal ulcer.

In an individual of middle age or beyond where symptoms have been of long duration, whose pylorus is markedly obstructed from scar tissue and adhesions and where gastric acidity is near normal, posterior gastro-enterostomy may be expected to give brilliant results. The principal redeeming feature of the operation, or perhaps it would be more accurate to say fallacy.

is that the technic of its execution is comparatively simple and the operator of limited experience feels justified in attempting its use.

One of the admonitions of the teacher of obstetrics is, "never pull on the umbilical cord in attempting to deliver the placenta for if it should pull off there is nothing left to pull on." This reminds me of the advocates of conservative surgery in the treatment of duodenal ulcers. Their admonition is, "never do a subtotal gastric resection as a primary operation in the treatment of duodenal ulcer, for if a marginal ulcer should develop then there is nothing left to resect." Marginal ulcers have occurred following subtotal gastric resection but even the most skeptic, I think, will have to admit that the incidence is small indeed as compared to that following gastro-enterostomy. Our end-results certainly have been much more satisfactory when resection was used instead of more conservative measures. With proper skill and experience the mortality from subtotal resection can be kept at a figure that would seem justifiable in the treatment of both gastric and duodenal ulcers.

Straus, *et al.*,³ in a recent article, report a mortality rate of 3.8 per cent in free ward cases and less than 2 per cent in private patients, a record so far as I know that has not been equaled by anyone else.

In 1925,⁴ and again in 1928, Devine⁵ of Australia called attention to the principles of pyloric exclusion in the treatment of duodenal ulcers. He recommended it particularly in old callus ulcers on the posterior wall of the duodenum when resection of the ulcer was difficult and dangerous and when recurrence of the ulcer occurred after gastro-enterostomy. He found that the nearer the resection of the stomach was made toward the cardia the more rapid was the emptying time and the greater the regurgitation of the alkaline duodenal contents as shown by the inorganic chloride curve. The free hydrochloric acid was lower and the end-results more satisfactory. In fact, gastric analysis was the same or perhaps a little better than in a gastric resection. Thus, he says, was evolved an operation as simple as a gastro-enterostomy giving the same results without the mutilation of a gastrectomy. He points out that if a reestablishment of the original condition seems desirable all the structures are available. It is necessary in his experience to exclude from one-half to two-thirds of the stomach to secure uniformly satisfactory results. This is best accomplished by making the section of the stomach very obliquely so as to include more of the gastric canal and exclude as much as possible of the fundus and its acid producing glands.

In ten cases I have used the principle of pyloric exclusion as recommended by Devine and the results so far have been most satisfactory. This method proved to be of particular value in a debilitated individual whose ulcer, some months following suture for perforation, began to bleed intermittently but alarmingly. Exploration after repeated transfusions revealed a large indurated prepyloric ulcer adherent to the pancreas. The patient probably would not have survived anything more radical than a pyloric exclusion and anything of less magnitude probably would not have relieved the symptoms. It has now been three years since operation and there has

been no return whatever of gastric symptoms. The warning by Devine of the inapplicability of this procedure in the presence of any pyloric obstruction was not sufficiently heeded in one instance. Subsequent to operation distension of the distal segment was palpable through the abdominal wall but fortunately a tube was inserted before rupture into the abdominal cavity occurred. Subsequently the pyloric obstruction subsided under rest and the gastrostomy opening healed.

A more widespread utilization of the principle of pyloric exclusion from my small but very satisfactory series would seem justifiable.

In the surgical treatment of gastric ulcers subtotal resection, I believe, is the operation of choice. It offers the greatest reassurance against recurrence and the possibility of the ulcer being or becoming malignant must never be lost sight of, hence the advisability of wide excision. Local excision of ulcers such as saddle excision of those along the lesser curvature give a high percentage of unsatisfactory results due to interference with gastric motility. If this method of treatment is to be used it should always be combined with a posterior gastro-enterostomy. Our experience with three cases in which a subsequent gastro-enterostomy had to be done to relieve retention has fully convinced me of the correctness of this conclusion. Sleeve resection for the same reason is a procedure that has little in its favor.

One condition that may closely simulate a lesion producing pyloric obstruction is that of constriction of the terminal duodenum by the superior mesenteric vessels. A brief résumé of such a case may prove instructive though reflecting little glory on the acumen of the surgeon.

The patient with a history of abdominal distress, nausea and vomiting with a large six hour retention was operated upon with a preoperative diagnosis of pyloric obstruction probably from a cicatrizing duodenal ulcer. No ulcer could be found from external investigation of the duodenum so an incision was made across the pylorus extending above into the stomach and below into the duodenum. Inspection of the interior of the duodenum was negative. The ends of the incision were approximated, converting the exploratory incision into a pyloroplasty. The subsequent course was that of aggravation of the symptoms of pyloric obstruction and roentgenograms showed persistence of the gastric retention. It was then thought that a gastro-enterostomy would relieve the symptoms, but this also failed in its mission. The gastric retention was relieved but the patient continued to vomit and complain of severe pain across the middle of the back. At no time did the roentgenologic investigation suggest duodenal obstruction, though this was thought of, and search for this condition carefully made. At the third operation nine months after the first, which was of an exploratory nature, with the thought in mind that a marginal ulcer might be present, no ulcer was found but a very definitely constricted terminal duodenum with dilatation proximally caused by the superior mesenteric vessels being drawn tightly across the duodenum. A pyloric exclusion was done by severing the stomach just distal to the gastro-enterostomy stoma. A duodenojejunos-

tomy was then made anastomosing the jejunum just distal to the gastro-enterostomy stoma to the third portion of the duodenum. Subsequent to the third operative procedure the patient made a very satisfactory recovery both as regards the nausea and vomiting and the pain in the back. The

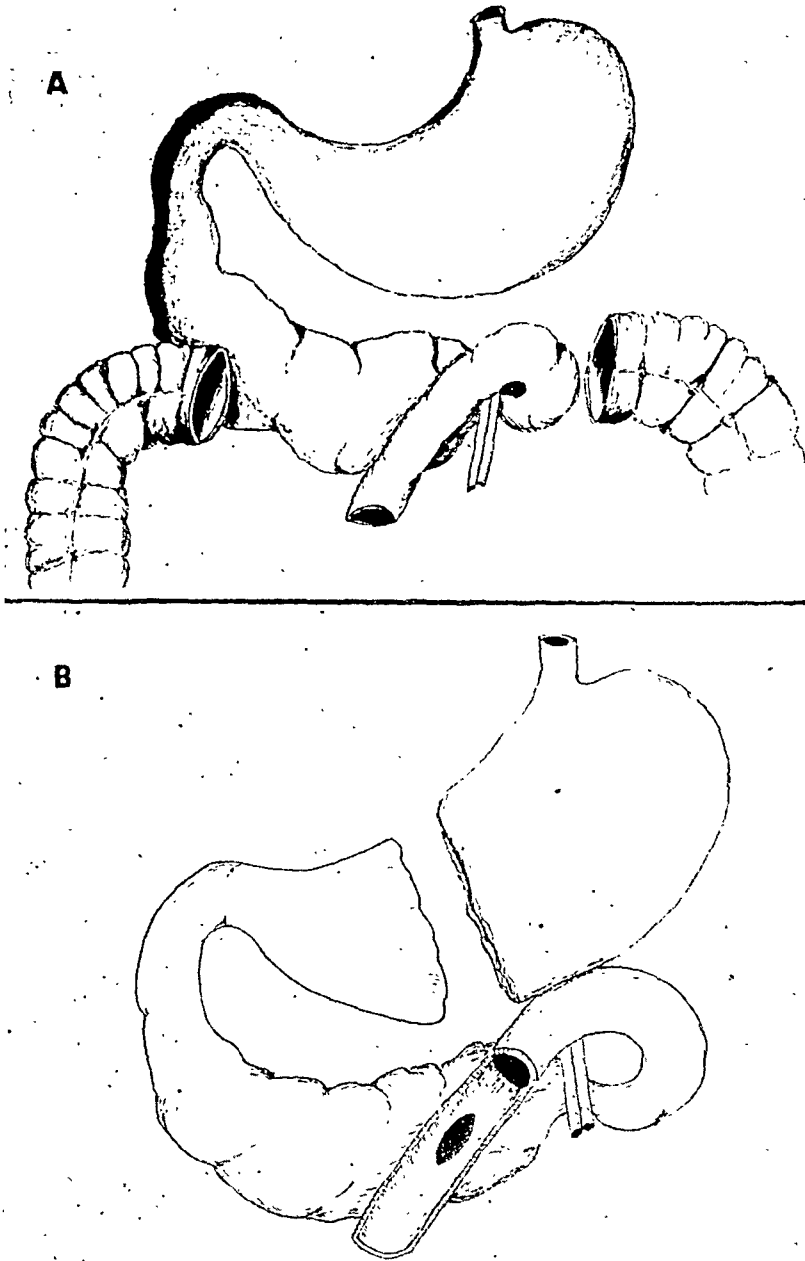


FIG. 3.—(A)—Obstruction of duodenum by superior mesenteric vessels. (B)—Showing gastro-enterostomy, pyloric exclusion and duodenojejunostomy used in treatment of case discussed in text.

lesson I have learned from this distressing case is to always investigate the duodenum, being especially careful to do so when not enough pathology is found higher up to account for the symptoms.

Acute perforation of the stomach or duodenum has been encountered 20 times. In the majority of instances the perforation was in juxtaposition

to the pylorus, it frequently being impossible, due to surrounding inflammatory changes, to determine whether the ulcer was duodenal or prepyloric. In no instance, so far as we have been able to determine, was the perforation the result of malignancy. When the perforation has occurred a sufficient distance from the pylorus and the induration about is not too great, inversion of the perforated area is desirable. When inversion will likely result in obstruction of the pylorus, or the surrounding induration makes such a procedure impractical, approximation of the edges of the perforation by chromic sutures covered over by one or more layers of omentum and at times the round ligament suffices to take care of the situation. At times when the ulcer is small and situated at or very near the pylorus, it may be excised by including it in a pyloroplasty incision. This has the advantage of

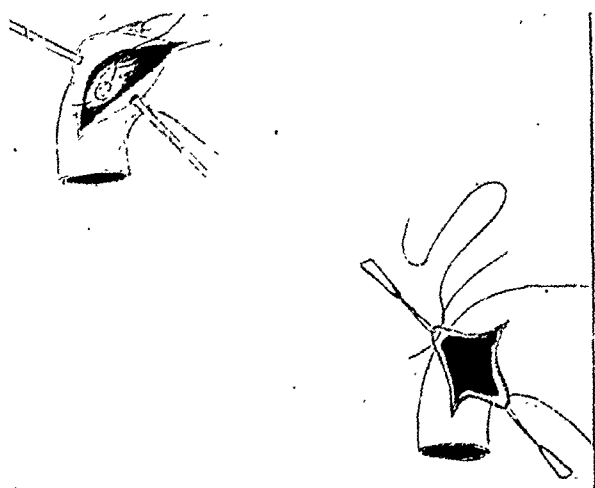


FIG. 4.—Showing method of controlling hemorrhage from duodenal ulcer on posterior wall and conversion of incision into pyloroplasty.

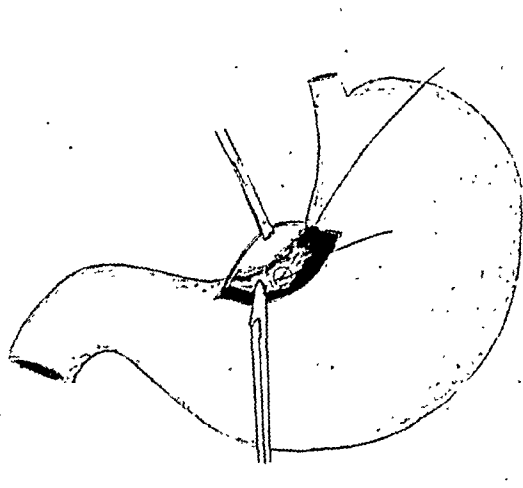


FIG. 5.—One method of controlling bleeding from ulcer on posterior wall of lesser curvature of stomach.

not only caring for the existing emergency but at the same time contributes so definitely toward prevention of further symptoms as to justify its use in selected cases.

Unless the perforation has been of sufficient duration to produce walled off areas with the development of abscess pockets the institution of drainage is of doubtful value. Cleansing of the abdominal cavity of food particles and sucking out of the accumulated exudate is sufficient. Drainage will not prevent an impending peritonitis and collections of pus can be drained to better advantage if and when they occur. Whenever drainage seems indicated it is important to use only rubber tissue and to be certain that it does not come in close proximity to the region of the perforation. Some individuals are apparently cured by the ulcer perforating but the percentage I believe is comparatively small. One case survived the closure of his first perforation but succumbed from the second catastrophe two years later.

The proper handling of the bleeding gastric or duodenal ulcer at times taxes the best judgment of both internist and surgeon. It has been the experience of the majority of observers that such cases will clear up by conservative measures. Persistence in this faith at times reduces the indi-

vidual to such a state that he will not survive operative interference, and medical treatment proves futile. It has been our experience that repeated blood transfusions are often life saving and we do not in the slightest degree subscribe to the idea that transfusions raise the blood pressure and are likely to do more harm by blowing out the clot than they are likely to do good. If operation is decided upon, a cannula tied into a vein with a battery of immediately available donors to be used before, during and after operation is a set up that is indispensable.

If possible, it is extremely desirable to tide the patient over the acutely bleeding period, for if it becomes necessary to subject him to surgery because of hemorrhage only the most conservative procedure that will arrest the hemorrhage is permissible. Rarely will this be of a curative nature. If the bleeding is from a duodenal ulcer it usually is situated on the posterior wall. It may be necessary to approach the ulcer by opening the duodenum ligating the bleeding vessel from within or by placing sutures about its base from without or by a combination of both. The incision may be prolonged across the pylorus into the stomach and converted into a pyloroplasty. If the hemorrhage is from a gastric ulcer, plunging a cautery through its base with suturing of the opening reinforced by a patch of omentum may suffice. In case the ulcer lies on the posterior wall and the gastrohepatic ligament above is thick and edematous, and the ulcer not easily approached by this route, an opening in the anterior wall will permit of suture or cauterization and suture from within.

Each situation must be dealt with as found, always remembering that the object of the operation is to control the bleeding point in the most conservative manner possible. It is also to be remembered when the bleeding is from the duodenum that the demonstration of an ulcer may not always be possible. Duodenitis as pointed out recently by Westermann⁶ may give rise to severe bleeding and the short circuiting of the outflow of gastric contents around the involved area is the only method of approach that offers much opportunity for cure.

SUMMARY.—(1) Duodenal ulcer is a medical problem unless complications arise.

(2) Gastric ulcer is a surgical problem unless quickly responding to medical treatment.

(3) Gastric carcinoma by whom and by what method treated reflects little if any glory on medical progress.

(4) Duodenal ulcers when subjected to surgery may be treated conservatively in selected cases but give the best end-results after subtotal resection.

(5) Subtotal resection is the method of choice in the surgical treatment of gastric ulcers.

(6) Pyloric exclusion has given excellent results in selected cases and probably is deserving of more attention than it has received in the past.

(7) In gastroduodenal perforations and hemorrhage only sufficient interference to care for the existing emergency is justifiable.

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PERITONITIS AS A FACTOR IN THE MORTALITY OF GASTRO-INTESTINAL SURGERY

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THE observation that peritonitis is a frequent cause of death following operations upon the gastro-intestinal tract has led to the assumption that the contamination of the peritoneal surfaces with intestinal contents during the operative procedure is responsible for this peritonitis. As a result, we find that the measures to prevent this fatal peritonitis have consisted in first, the proposal of the various more or less complicated "aseptic" methods of anastomosis, and secondly, in peritoneal vaccination to increase the resistance of the peritoneum to this slight contamination. There are certain considerations, however, which question operative soiling as the important cause of fatal peritonitis. The natural defensive powers of the peritoneum in experimental animals¹ are sufficiently great to withstand a definite and considerable inoculation with bacteria, except those of great virulence, providing this inoculation is not a prolonged feeding-in of organisms as from a suppurative focus or from an opening into the lumen of the bowel. That the peritoneum in man is probably almost equally resistant is evidenced by the frequent prompt recovery from peritonitis after the surgical removal of a gangrenous appendix. In addition, we have the clinical observation that there is frequently more or less unavoidable soiling when the bowel is opened at operation, and yet fatal peritonitis is the exception in such cases rather than the rule.

The study which forms the basis for this communication was undertaken to determine the relative importance of peritonitis as a cause of death following operative procedures upon various parts of the gastro-intestinal tract, and to investigate the cause of the peritonitis in these fatal cases. The deaths following gastro-intestinal surgery at the Peter Bent Brigham Hospital from 1913 to the present time were analyzed, including in this study only those which were submitted to postmortem examination. Fatalities after simple exploratory laparotomy were excluded, as well as cases in which peritonitis was found to be already present at operation or where the operation was undertaken for a primarily inflammatory condition. A total of 91 cases were thus available for study. Of this number, 23 or one-fourth died of peritonitis. The findings were as follows:

GASTRIC SURGERY.—There were 25 autopsied fatalities and in these the operative procedure had been gastric resection in 13 cases, gastrojejunostomy in nine cases, gastrojejunostomy with pyloroplasty in three cases, and gastrotomy in one case. In eight patients the operation had been undertaken

for peptic ulcer and in the remaining 17 for carcinoma of the stomach. The causes of death are detailed in Table I.

TABLE I
CAUSES OF DEATH IN 25 CASES OF GASTRIC SURGERY

Pneumonia.....	8 cases
Circulatory failure.....	4 cases
Pulmonary abscess.....	3 cases
Pulmonary embolus.....	2 cases
Obstruction.....	1 case
Hemorrhage.....	1 case
Duodenal fistula.....	1 case
Septicemia (from hypodermoclysis).....	1 case
Peritonitis.....	4 cases (16 per cent)
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Total.....	25

Closer inquiry into the four instances of fatal peritonitis reveals the following:

Case S. 18417.—Male, aged 51. Gastric resection, Billroth I, for carcinoma. Died in five days. Autopsy showed bronchopneumonia with generalized peritonitis due to perforation of the anastomosis.

Case S. 28192.—Female, aged 35. Excision of pylorus and posterior gastrojejunostomy for duodenal ulcer. Died in 13 days. Autopsy showed generalized peritonitis. The anastomosis was open, partially walled off by fresh adhesions.

Case S. 12135.—Female, aged 47. Gastric resection, Billroth II, for carcinoma. Jejunostomy four days later for obstruction. Died 14 days later. Autopsy showed bronchopneumonia and peritonitis with leakage at the anastomosis apparently due to tension by too short a loop of jejunum.

Case S. 38016.—Male, aged 73. Posterior gastrojejunostomy for carcinoma. Died in eight days. Autopsy showed bronchopneumonia and generalized peritonitis without any definite focus.

SMALL BOWEL SURGERY.—There were 14 autopsied fatalities. In nine of these the operative procedure was resection, in five enterostomy, and in one enterotomy. In every instance surgery had been undertaken because of intestinal obstruction. In eight patients the obstruction was caused by a strangulated hernia, in three by adhesions, and in the remaining three by carcinoma, mesenteric thrombosis and impacted gallstone, respectively. In all of these patients the physiologic depletions associated with the obstructive condition doubtless played a more or less important part in the fatal outcome;

TABLE II
CAUSES OF DEATH IN 14 CASES OF SMALL BOWEL SURGERY

Pneumonia.....	7 cases
Circulatory failure.....	4 cases
Parotitis.....	1 case
Peritonitis.....	2 cases (14 per cent)
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Total.....	14

aside from this factor the causes of death as disclosed at autopsy are detailed in Table II.

Both instances of peritonitis occurred in the resection group, the circumstances being as follows:

Case S. 30073.—Male, aged 59. Resection of ileum and end-to-end anastomosis for strangulated femoral hernia of two days' duration. Died in nine days. Autopsy showed generalized peritonitis. The margins of the stoma were gangrenous due to impaired blood supply.

Case S. 21876.—Female, aged 66. Strangulated femoral hernia of five days' duration. Resection of gangrenous ileum by a modified Mikulicz procedure. Considerable fecal leakage at operation. Died the following day. Autopsy showed generalized peritonitis without any definite focus.

LARGE BOWEL SURGERY.—There were 52 autopsied fatalities. In 48 of these the operation had been undertaken for carcinoma, distributed as follows: proximal colon nine cases, transverse colon two cases, distal colon 18 cases, rectum and rectosigmoid 19 cases. In the remaining four patients operation was for relief of obstruction due respectively to volvulus, hernia, adhesions and anal stricture. The operative procedure was confined to colostomy in 20 instances. The causes of death are detailed in Table III.

TABLE III

CAUSES OF DEATH IN 52 CASES OF LARGE BOWEL SURGERY

Pneumonia.....	19 cases
Circulatory failure.....	9 cases
Intestinal obstruction.....	4 cases
Pelvic cellulitis and septicemia.....	2 cases
Pulmonary embolism.....	1 case
Peritonitis.....	17 cases (33 per cent)
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Total.....	52

Four of the cases of peritonitis followed simple colostomy:

Case S. 3627.—Male, aged 53. End type sigmoidostomy for inoperable carcinoma of the sigmoid. Died in three days. Autopsy showed a perforation of the bowel wall through the carcinoma and a large pelvic abscess.

Case S. 29532.—Male, aged 74. End type sigmoidostomy for carcinoma of the rectum. Died in two days. Autopsy showed bronchopneumonia with peritonitis from wound infection and necrosis of the abdominal wall.

Case S. 42748.—Male, aged 71. Transverse loop type colostomy for carcinoma of the splenic flexure. Died the following day. Autopsy showed generalized peritonitis with a perforation of the bowel through the carcinoma.

Case S. 26006.—Male, aged 51. Cecostomy for carcinoma of the sigmoid. Gross fecal contamination at operation. Died in seven days. Autopsy showed generalized peritonitis with no definite focus.

The remaining 13 instances of fatal peritonitis followed more extensive procedures. In this group there were six cases in which the peritonitis was caused by a defect in the bowel wall.

Case S. 18917.—Female, aged 55. Side tracking ileosigmoidostomy for carcinoma of the transverse colon. Died in ten days. Autopsy showed generalized peritonitis with a perforation of the colon through the tumor.

Case S. 22003.—Male, aged 71. Transverse colostomy followed in two days by resection of sigmoid for volvulus and removal of a congested appendix. Died in nine days. Autopsy showed generalized peritonitis. The appendix stump was open.

Case S. 16555.—Male, aged 48. Resection of carcinoma of the splenic flexure with end-to-end anastomosis and cecostomy. Died the following day. Autopsy showed generalized peritonitis. The Mixter tube had torn out of the cecum and the contents were flowing out freely into the peritoneal cavity.

Case S. 48382.—Male, aged 32. Side tracking ileotransverse colostomy for carcinoma of the cecum. Died in seven days. Autopsy showed generalized peritonitis. Both the anastomosis and the distal stump of ileum had opened.

Case S. 26063.—Male, aged 73. Cecostomy followed in 18 days by resection of carcinoma of the sigmoid and end-to-end anastomosis. Died in five days. Autopsy showed generalized peritonitis. The sutures had given way at two points allowing fecal extrusion.

Case S. 31188.—Female, aged 38. Resection of carcinoma of the sigmoid by a modified Mikulicz procedure. Died in three days. Autopsy showed generalized peritonitis. There was a perforation 3 Mm. in diameter in the proximal limb, due apparently to a slough caused by a suture tacking a fat tab to the bowel wall.

There were four cases caused by a septic focus due to vascular interference.

Case S. 39526.—Male, aged 69. Cecostomy followed in seven days by resection of carcinoma of the splenic flexure by a modified Mikulicz procedure. Died in seven days. Autopsy showed generalized peritonitis and lobar pneumonia. The distal limb of sigmoid was gangrenous.

Case S. 12654.—Female, aged 59. First stage of abdominoperineal operation for carcinoma of the rectum. Stump of sigmoid turned down into pelvis. Died in four days. Autopsy showed generalized peritonitis and bronchopneumonia. The sigmoid stump was gangrenous and the reconstructed pelvic floor had sloughed.

Case S. 42526.—Male, aged 65. First stage of abdominoperineal operation for carcinoma of the rectum. Stump of sigmoid turned down into pelvis. Died in five days. Autopsy showed generalized peritonitis and bronchopneumonia. The sigmoid stump was gangrenous and pus was flowing up through a leak in the reconstructed pelvic floor.

Case S. 22780.—Male, aged 68. Abdominoperineal resection for carcinoma of the rectosigmoid. Died in five days. Autopsy showed bronchopneumonia and generalized peritonitis. The reconstructed pelvic floor had sloughed, allowing purulent contamination from the posterior wound.

In two instances operation was performed through a septic field.

Case S. 38593.—Male, aged 45. Ileotransverse colostomy followed in 11 days by resection of carcinoma of the hepatic flexure. The growth was incompletely removed and necrotic purulent tissue was broken into during the procedure. Died in six days. Autopsy showed generalized peritonitis. Anastomosis was intact and there was no definite focus.

Case S. 30774.—Female, aged 31. Resection of extensive carcinoma of the transverse colon involving a loop of ileum and the sigmoid. Operation was performed through the septic field of a fecal fistula resulting from an exploratory operation six weeks previously. End-to-end repair of ileum and sigmoid; Mikulicz procedure to transverse colon. Autopsy showed generalized peritonitis with a necrotic abscessed area in the region of the Mikulicz colostomy.

In one instance fecal contamination at operation was apparently responsible.

Case S. 28636.—Male, aged 60. Resection of carcinoma of sigmoid with end type sigmoidostomy. Operator's note mentions considerable fecal soiling due to slipping clamp. Died in six days. Autopsy showed a generalized peritonitis with no definite focus.

COMMENT.—It is interesting to note that the most important cause of death after operations on the gastro-intestinal tract proved to be pneumonia and not peritonitis. This was true even in the case of large bowel surgery. Therefore, in endeavoring to lower the mortality in this group of patients it is apparent that measures to prevent postoperative pneumonia are of equal or greater importance than are efforts to prevent peritonitis. Such measures would include avoidance of surgery in the presence of acute upper respiratory infections, sitting the patient up in bed after operation, turning him frequently, getting him out of bed as soon as possible, prompt control of abdominal distention, cardiovascular stimulation when indicated, and possibly hyperventilation by means of carbon dioxide inhalations.

A study of the postmortem findings in the 23 cases of fatal peritonitis reveals the significant fact that in all but six cases there was found a definite focus of contamination. This focus proved to be a grossly leaking anastomosis in five cases, a perforation through a carcinoma in three cases, and a fecal leak in three other cases, due, respectively, to an open appendiceal stump, the slough caused by a tight suture, and the tearing out of a cecostomy tube. In five cases the infective focus was gangrenous bowel caused by impaired blood supply, and in one case the focus was a fulminating wound infection involving all layers of the abdominal wall.

In only six instances, therefore, could the fatal peritonitis be attributed to contamination of the peritoneal surfaces at operation. In two of these six cases the operator mentions in his note that there was gross soiling with feces by the unexpected slipping of a clamp. In one instance the operation was performed through a septic field caused by a fecal fistula, and in another the peritoneum was grossly contaminated by breaking into foul necrotic cancerous tissue. There are left, then, only two instances in which, following an uncomplicated operation on the stomach or bowel, the patient died of peritonitis which could be fairly attributed to the slight unavoidable peritoneal contamination involved in these procedures.

The five cases in which the cause of the fatal outcome was a leaking anastomosis deserve closer scrutiny. The interval between operation and the clinical manifestation of peritonitis was in two cases three days, in one case five days, and in two cases eight days. Death occurred two to six days later. In four of the five cases the anastomosis was made with chromic catgut, used as continuous sutures of size number one; a first through and through and a second sero-serous. In the fifth case a gastroduodenal anastomosis had been reinforced anteriorly with interrupted silk sutures. The defect in the suture line found at autopsy, however, was situated on the

posterior aspect of the anastomosis. It seems reasonable, therefore, to believe that the use of non-absorbable sutures, at least in the outer row of stitches, might have prevented the leak in some of these cases.

CONCLUSIONS

(1) Peritonitis accounts for about one-fourth of the fatalities of gastrointestinal surgery.

(2) The incidence of fatal peritonitis after operations on the large bowel is about twice that following operations on the stomach or small bowel.

(3) Pneumonia is a more frequent fatal complication than peritonitis, accounting for over one-third of the fatalities.

(4) The resistance of the human peritoneum to a bacterial contamination is great. Operative fecal soiling, unless massive, rarely causes fatal peritonitis.

(5) Of the cases of fatal peritonitis studied, only one-fourth could be attributed to operative soiling. The rest were due to gross leakage resulting from a defective anastomosis or from perforation elsewhere, to gangrene resulting from impaired blood supply, or to a suppurative focus in the wound or retroperitoneum.

(6) In the prevention of fatal postoperative peritonitis, accurate suturing with careful attention to blood supply is of greater importance than strict asepsis.

(7) The elaborate methods of anastomosis which emphasize speed and asepsis may prove to be less safe than the more simple and precise methods.

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INDUCED AND SPONTANEOUS CHANGES IN BLOOD AMYLASE PARTICULARLY IN RELATIONSHIP TO THE PANCREAS

AN EXPERIMENTAL STUDY

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It is generally conceded that the pancreas exerts a profound influence upon the amylolytic potency of the blood serum, and that following experimental occlusion of the pancreatic ducts there is a sharp increase in potency followed by a decline to approximately normal or even subnormal values. The effects of pancreatectomy, however, have been a subject of controversy; and, although most recent investigators have reported an immediate post-operative decrease in serum amylolytic power, there is disagreement as to whether or not a return to normal occurs in animals treated with insulin.

The immediate effects of experimental occlusion of the pancreatic ducts were reported in 1908 by Schlesinger.¹ These results have since been confirmed. A twentyfold rise in serum amylolytic potency following duct ligation is not uncommon. In the recent investigations of Elman, Arneson and Graham,² Johnson and Wies,³ and others^{4,5} a regression toward normal values, occupying several weeks, has been demonstrated. Schlesinger¹ studied also the effects of pancreatectomy, and observed in two dogs and one cat a prompt postoperative diminution in potency of serum diastase. Most other investigators have had similar results, but several^{6,7,8,9} have reported no change or an increase. The literature has been reviewed by Elman and his collaborators² and by McCaughan.⁵ In some of the early experiments however, it is doubtful that complete pancreatectomy was effected; and the reported spontaneous recoveries reflect laxity in this regard. A small fragment with obstructed ducts, inadvertently left behind at operation, might easily obscure any influence attributable to removal of the major portion of the gland. Furthermore, if the ducts are ligated early in the course of total pancreatectomy, there may be considerable backing up of amylase into the blood and lymph channels before removal of the gland is completed. Indeed, a fourfold increase in serum amylase may occur in dogs within 15 minutes after obstruction of the ducts.² Quite apart from these considerations, the weight of evidence indicates that pancreatectomy in dogs induces a prompt decline to approximately one-half or one-third the preoperative level.

Since the development of insulin therapy, it has been possible to maintain depancreatized animals alive and in good condition for long periods of time. Markowitz and Hough¹⁰ tested the serum amylolytic power in dogs which had been so maintained for several months, and reported normal values;

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whereas, in other experiments, they found characteristically decreased potency soon after pancreatectomy. They stated further that injection of insulin affected the blood diastases but slightly and in a variable manner. Reid, Quigley and Myers¹¹ reported likewise a postoperative decline soon followed by a rise to or above the preoperative level when diabetes was controlled by administration of insulin; but claimed that lapse in treatment induced a reduction in blood diastase, with a subsequent return to normal when insulin injections were resumed. On the other hand, Zucker, Newburger and Berg⁴ reported that in depancreatized dogs treated with insulin the serum amylolytic potency fell to less than half the preoperative level and did not recover. They estimated potency by means of a modification of Wohlgemuth's method, and made the interesting observation that the measured effect was less and inconstant when glycogen was used as substrate instead of starch.

This emphasized an urgent need of more critical examination of the methods employed to estimate amylolytic potency. The Wohlgemuth and the much more precise viscosimetric methods may be considered to reflect chiefly action upon α -amylase, the first stage in a cascade of reactions ending in sugar formation. On the other hand, the achromatic iodine methods measure a combined enzymic effect upon amyloses and erythrodextrins,¹² whereas those based on sugar formation may be influenced by enzymes affecting any stage or stages in the cascade. Indeed, some of these enzymes may act not at all upon the early stages of starch degradation, and have little claim to the name, *amylase*. Such an enzyme was found in malt extract by Wijsman¹³ in 1889, and Giesberger¹⁴ has claimed that a similar enzyme (so called β -*amylase*) occurs in pancreatin and in saliva. Under certain conditions, such an enzyme may be the pace-setter, or chief determinant of reaction speed. We do not wish to raise objection to all uses of technics based on sugar formation, but merely to indicate a possible source of some discrepancies, since Markowitz and Hough,¹⁰ and Reid, Quigley and Myers,¹¹ who employed such methods, are in disagreement with Zucker, Newburger and Berg,⁴ who did not. It is not at all certain that these investigators were measuring activity of the same enzyme; nor, indeed, that any of them were concerned throughout their experiments with a single enzyme or mixture in fixed proportions. From this point of view we have examined a precise viscosimetric method for estimation of amylolytic activity, which had been described previously^{15, 16}; and have shown¹⁷ that, measured in this way, the amylolytic potency of the serum of normal and of depancreatized dogs as well as that of dog pancreatic extract is attributable to one and the same chemical individual. Similarly,¹⁷ in the case of humans, one and the same chemical individual appears to be responsible for the amylolytic potency of serum, pancreatic extract, and saliva; although human, dog and hog amylases are readily distinguishable from each other.

In recent years a considerable literature has appeared in regard to the clinical value of serum amylase determinations in the diagnosis of human pancreatic disease. Normal variation has been explored, and it has been

shown^{2, 18, 19} that exceedingly high values are found consistently in acute pancreatitis. However, in chronic pancreatic disease normal values of serum amylase are encountered so frequently as to render the test of little value in such cases. Thus, in patients with carcinoma of the head of the pancreas, where progressive occlusion of the ducts is accompanied by progressive diminution of functioning acinar tissue, the concentration of serum amylase may be normal. The published clinical reports have largely been confined to single observations on any given individual.

It would seem preferable to study spontaneous variations in serum amylolytic potency with time; or, better still, to induce modification of pancreatic function and study consequent variations in potency. This would be analogous to the familiar use of histamine in gastric analysis. A possible basis for such a test in the case of the pancreas is suggested by the observations of Anrep^{20, 21} and Korovitsky,²² who indicated in acute experiments with dogs and cats that stimulation of the vagus may produce spasm of the pancreatic ducts as well as increased pancreatic secretion. Either or both of these mechanisms might induce a rise in serum amylolytic potency, and the character of the perturbation might furnish an indication of the functional ability of the pancreas. A prospective pharmacologic means to this end was suggested by the well-known fact that the physiologic action of acetylcholine and some of its derivatives simulates that of widespread parasympathetic stimulation. Furthermore, Antopol, Schifrin and Tuchman²³ found that injection of acetyl β -methylcholine chloride in normal dogs resulted in a prompt rise in serum amylolytic potency, and that the response could be inhibited by a preliminary injection of atropine or enhanced by eserine (physostigmine). The rôle of the latter as a protector of acetylcholine from physiologic destruction has been demonstrated in the experiments of Engelhart and Loewi.²⁴ Antopol and his collaborators did not suggest in their report that the rise in serum amylolytic potency reflects chiefly a pancreatic response. However, this seemed to us not at all unlikely, and confirmed us in our opinion that the possibilities of utilizing such means as an indicator of the functional ability of the pancreas should be investigated.

Accordingly, experiments were designed to bring evidence to bear on this question, and to elucidate the rôle of the pancreas in control of serum amylase concentration. The object of the present communication is to report the results of these investigations.

Technic in Experimental Research.—Amylolytic potency was measured by means of the viscosimetric technic^{15, 16} to which reference has been made. This is a method of high precision, with an estimated error in most instances less than 1.5 per cent. An arbitrary unit of amylase concentration based on potency under reproducible conditions has been developed^{25, 26} for hog pancreatin (Parke, Davis). The concentration of human serum amylase may be expressed conveniently in terms of an equivalence^{15, 17} which persists throughout the pH range investigated (5.1, 6.7). However, with dog serum amylase an equivalence established at one pH in this range would not

be valid at another.^{17, 27} Accordingly, we have adopted a unit for dog amylase concentration such that, under the conditions of measurement with the substrate, S_{55} , previously described,^{15, 16} equal concentrations of dog and hog pancreatic amylases have the same activity.²⁸ As in previous communications, we shall represent amylase concentration by Q , Q_s denoting the serum amylase concentration.

Dogs weighing about 15 to 20 Kg. and in apparently good health were selected for the experimental work, and were kept in clean, well lighted and ventilated, individual cages. Unless otherwise stated, the dogs were fed once daily, and normal animals were given a diet consisting chiefly of dog biscuit, with occasional bones, meat, milk and yeast. Other diets will be described in connection with individual experiments. Although there is reason to believe that in dogs so maintained little or no fluctuation in Q_s is to be associated with feeding, blood samples were taken not sooner than 12 hours after meals or insulin injection, except in special experiments where this was not feasible because of the frequent sampling required. For estimation of Q_s , about five milliliters of blood were drawn aseptically from a leg vein and allowed to stand at room temperature for a half hour in a rubber²⁹ stoppered centrifuge tube. This was then placed in a refrigerator for one-half to 16 hours, the clots broken, the capped tubes centrifuged at high speed for 20 minutes, and the serum decanted and stored in a refrigerator until used. Under these conditions serum may usually be kept for several days without much change in Q_s , but estimations were made on the same or following day in the large majority of instances.

Anesthesia for surgical operations was induced by intraperitoneal administration of sodium amytal in doses approximating 0.06 Gm. per Kg. of body weight.

Effects of Pancreatectomy on Serum Amylase Concentration.—After a short period of preliminary observation, the effects of pancreatectomy upon Q_s were observed in several experiments. During the course of excision of the gland particular care was taken to insure complete removal, and yet to avoid injury to the pancreatic ducts until the organ had been freed at all other points. The ducts were then ligated and severed, and the gland removed. Immediately after operation the animals were given 10 units of insulin, followed by hypodermoclysis or intravenous infusion of 500 Ml. of 5 per cent glucose in physiologic saline. A blood sample was taken just before operation but not again until the next day. The daily diet after operation consisted of about 500 Gm. of canned horse meat (Chappel Bros.), 200 to 300 Gm. of dog biscuit, 5 Gm. of brewers' yeast, 2 Gm. of pancreatin, and small amounts of lecithin. Administration of these latter preparations has been discussed in a recent article by Ivy.³⁰ Twenty to 30 units of insulin was given before feeding, and water was allowed ad lib. During the first postoperative day several small feedings were administered, each preceded by injection of five to ten units of insulin. Thereafter the amounts of food and insulin were adapted to the individual needs of animals. Occasionally,

fresh meat was substituted for the canned product; and, during certain periods to which reference will be made below, pancreatin was omitted from the diet in order to ascertain whether or not an appreciable effect on Q_s might be manifested. Under this regimen, animals were maintained in fairly good condition although the urine was not kept sugar free.

Results thus obtained with three normal dogs (Nos. 1, 2, and 3) subjected to pancreatectomy are presented in Chart 1.

In each instance there was a sharp decline in Q_s , apparent as early as the first postoperative day. For comparison, three levels, M, A, and B, are

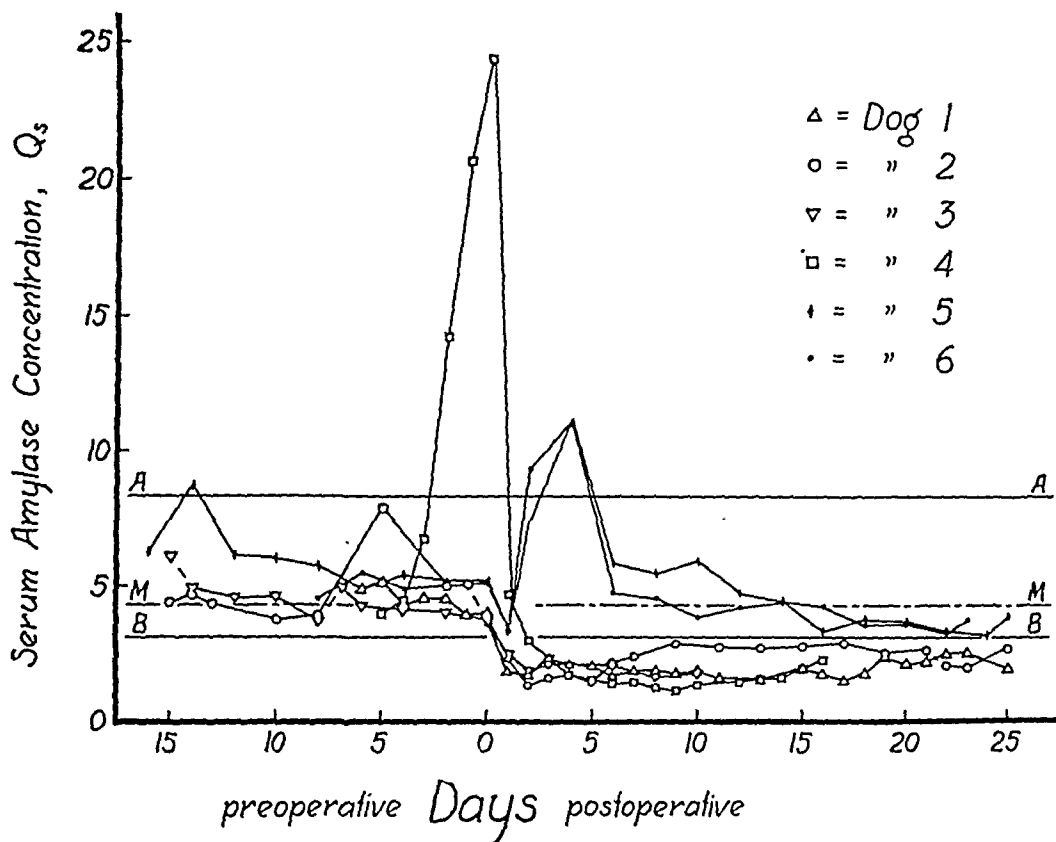


CHART 1.—Effects on Q_s of pancreatectomy (Dogs 1, 2, 3 and 4) and of formation of gastric pouch (Dogs 5 and 6). M is the median of observed normal values, 5 per cent of which lay above A and an equal number below B.

given representing statistics obtained from 144 observations on 13 presumably normal dogs.³¹ These observations lay in equal numbers above and below the level M, the median (4.26), whereas only 5 per cent lay above A and an equal number below B. In presumably normal animals there were occasional large spontaneous excursions above the median value. These were usually characterized by a gradual rise in Q_s , occupying several days, and a return to normal which was almost a mirror image of the rise. The similarity of this picture and that found in cases of acute pancreatitis or obstruction of the pancreatic ducts suggested that the observed spontaneous perturbations reflect mild and transient disturbances of like nature. With this in mind, a close watch was kept for such excursions. The most extensive in our experience occurred in Dog 4; and, at a time when the serum amylase was still

rising, pancreatectomy was performed. This initiated a precipitate decline in Q_s (Chart 1). Except for the value obtained in this animal on the first day after operation, all observations on depancreatized dogs recorded in the chart lie below the level B, whereas only 5 per cent of the values for normal dogs do.

The pancreas of Dog 4 appeared normal in gross at the time of operation. From various portions of the excised gland six histologic sections were made, three of which—from the proximal portion of the head and an adjacent part of the body—revealed on microscopic examination a few minute areas of necrosis. The most striking lesions involved the interstitial adipose and connective tissues, and presented a characteristic aspect of fat necrosis. In the middle of such a lesion (Fig. 1) the adipose tissue cells were replaced by an amorphous, pink-stained mass, which was surrounded by a fairly

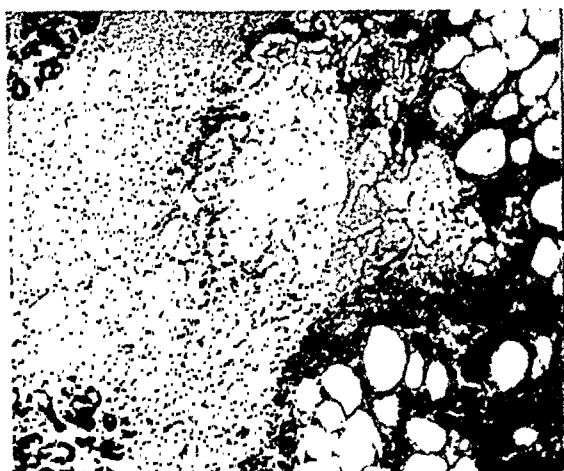


FIG. 1.—Photomicrograph of a region of fat necrosis which occurred spontaneously in the pancreas of Dog 4.

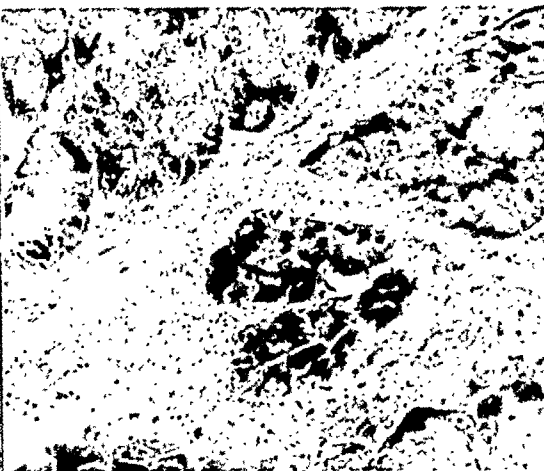


FIG. 2.—Photomicrograph showing contiguous acinar and septal necrosis in the pancreas of Dog 4 in contrast with normal acinar tissue in the upper left corner.

dense cellular zone of infiltration, composed chiefly of polymorphonuclear leukocytes and small round cells. Many of the nuclei were pycnotic and some were fragmented. There were a few young fibroblasts at the periphery of the lesion. Some lesions were found in portions of the interlobular septa where little or no adipose tissue occurred; and were characterized by a granular, semi-opaque appearance, with loss of cellular outline, scattered nuclear fragments and basophilic stippling. A connection of necrotic tissue could frequently be traced through the septa between fairly remote lesions, which indicates that necrosis had probably spread along the interstitial tissues. Evidence of early necrosis was observed in some of the acini, but only in lesions adjoining necrotic septa. The acinar lesions were well defined in only one section, and were characterized by shrunken and fragmented cells with pycnotic nuclei and deeply stained basophilic cytoplasm (Fig. 2).

On the whole, there was a remarkable paucity of parenchymatous involvement. The insular tissue and pancreatic ducts were normal in appearance throughout, and the latter contained little or no debris. All the sections

revealed diffuse interstitial edema and subcapsular hemorrhage which, however, might have been the result of trauma during excision of the gland.

Several days after operation this dog developed rhinitis and conjunctivitis, and within a week had unmistakable signs of distemper. It would seem probable in retrospect, that the animal was in the invasive stage of the disease at the time of operation. Thus a question arises as to the possible etiologic rôle of distemper in production of the pancreatitis. Although nodular fat necrosis of the pancreas is said³² to occur in "absolutely normal lobules in fattened pigs" and also exceptionally in the dog where it may produce "no symptoms," the occurrence of lesions such as we have described has apparently not been reported in connection with distemper.³³ As to the spontaneous increase in Q_s , we have observed similar but much less extensive perturbations in other presumably normal dogs. Only one of these (Dog 12) developed distemper subsequently, but it is interesting to note that the extent of rise in this case was second only to that observed in Dog 4, and coincided with the invasive stage of the disease. Daily observations on Dog 12 gave the following values of Q_s : 3.80, 3.88, 3.81, 3.47, 3.79, 4.84, 5.10, 9.70, 11.48, 9.82, 6.01, 3.95, 4.57, 3.49, 3.55, 3.58.

Dog 4 was sacrificed on the sixteenth postoperative day and no remaining pancreatic fragments were found. Postmortem examination of other dogs subjected to pancreatectomy likewise revealed no pancreatic tissue.

A crude control as to the possible influence of dietary change following pancreatectomy is afforded by observations on Dogs 5 and 6, which for a week preceding operation were placed on the regimen for depancreatized dogs, except that insulin, pancreatin and lecithin were not supplied. In both animals Q_s was close to the normal median throughout this interval. It might be supposed that the decline in Q_s after pancreatectomy in Dogs 1, 2, 3 and 4 is not specifically referable to extirpation of the pancreas, but might follow any extensive operation which interferes with the animal's nutrition. In order to furnish some control in this regard, Dogs 5 and 6 were subjected to the formation of gastric pouches. In one instance (Dog 5) a pyloric pouch was made, and in the other a pouch including portions of both pylorus and antrum. Immediately thereafter these dogs were fed milk until they would again accept the preoperative diet, which was thereupon substituted. Effects on Q_s , represented in the same figure, offer a considerable contrast with those for depancreatized animals.

As mentioned in the introduction, a difference of opinion is expressed in the literature as to whether or not there is a tendency for serum amylase concentration to return to a normal level after pancreatectomy. Two of our animals were maintained for a period in excess of four months following this operation, and Q_s was measured frequently (Chart 2).

A, B and M have the same significance as before. There is no apparent tendency for the serum amylase concentration to rise to the preoperative level; and, indeed, all observations but one lie below the level B.

Pancreatin was omitted from the diet of Dog 4 during the first six post-

operative days, and from that of Dog 1 before the nineteenth and after the one hundred and thirteenth postoperative days. This did not seem to influence Q_s as may be seen in the first two charts. Several of the dogs there represented were used in special experiments involving subcutaneous injection

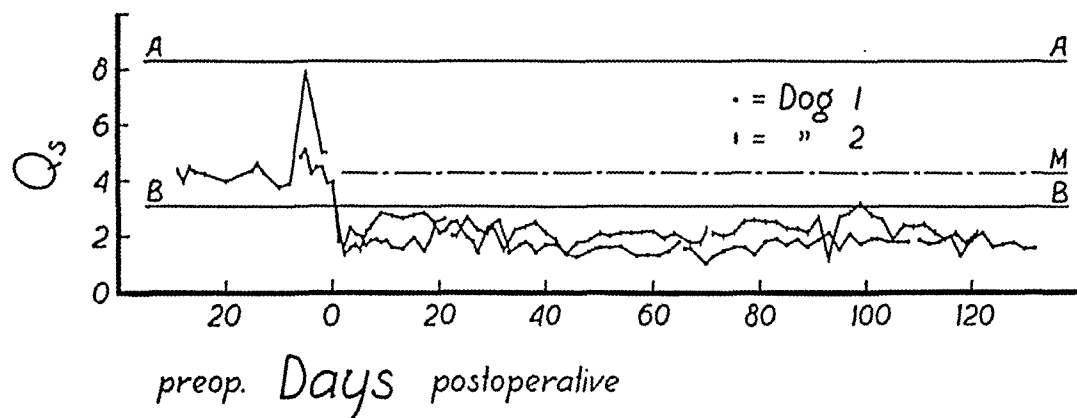


CHART 2.—Extended observations on two depancreatized dogs, showing no return trend of Q_s toward the range (A, B).

tion of acetyl β -methylcholine chloride and eserine sulphate. Observations showing the response to such administration will be presented below, but are omitted from Charts 1 and 2, where a broken line between recorded points indicates such omission. Whatever effects upon Q_s followed injection, they were usually inappreciable after the lapse of a day. Exclusive of the first

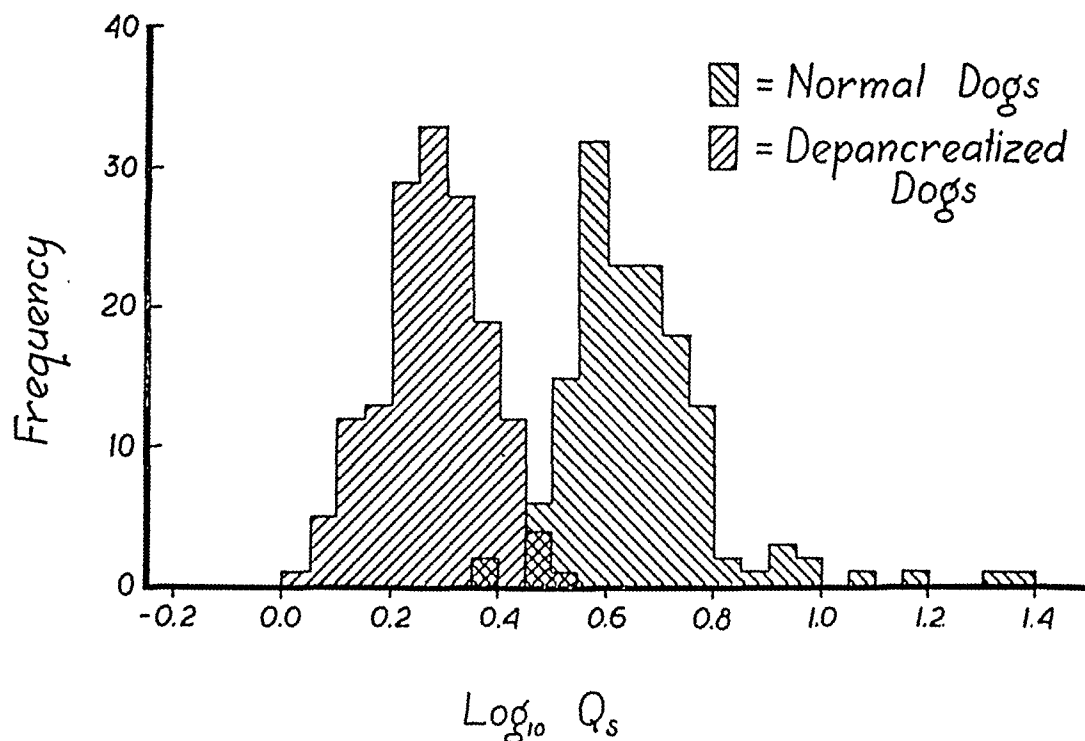


CHART 3.—Frequency-distribution of $\log Q_s$ in observations on presumably normal and on depancreatized dogs.

observation made on the day after such injection and those of the intervening period, there were 144 observations on 13 presumably normal dogs, and 157 observations made on four depancreatized dogs after the first postoperative day. Although these groups are not composed of strictly in-

dependent observations, their frequency-distribution diagrams, given in Chart 3 are illuminating.

Log Q_* is used as variate instead of Q_* for convenience in graphic presentation. The median for the normal dogs is appreciably higher than that for the depancreatized animals; and, indeed, the two sets of observations show remarkably little overlap. A tendency in presumably normal dogs to greater spontaneous excursion above the median than below is evident even in the logarithmic graph by the asymmetry of distribution. The absence of such asymmetry in the case of the depancreatized animals sustains the contention that large spontaneous increases in Q_* are the result of pancreatic disturbance.

Effects of Acetyl β -methylcholine Injection upon Serum Amylase Concentration in Relation to Functional State of the Pancreas.—As has been mentioned in the introduction, injection of acetyl β -methylcholine in normal dogs may greatly increase the serum amylase concentration. Our first purpose in the following investigations was to ascertain whether or not this response could be definitely related to the pancreas. In all these experiments a standard dose was adopted, which consisted of 0.5 mg. of acetyl β -methylcholine chloride (Merck) per Kg. of body weight and 1 mg. of eserine sulphate (Wyeth) in physiologic saline, administered by subcutaneous injection. Q_* was measured immediately before and frequently for several hours thereafter. The animals were given an extra meal on the preceding night, and were not fed again until approximately six hours after the injection. Results thus obtained with seven normal dogs are represented in Chart 4.

In each instance there was a sharp rise in Q_* , although a considerable variation in the extent of the response is apparent. A peak was attained within a few hours, and within a day's time most of the increment in Q_* was spent. One of these dogs (No. 2) was later subjected to pancreatectomy, and the injection was repeated on the twenty-first and seventieth postoperative days. The lack of response, illustrated in the same chart, contrasts strikingly with the normal reaction of the same and other dogs. That this cannot be attributed solely to a developed tolerance is indicated by similar results obtained with another depancreatized dog (No. 1 in Chart 4) which had not received such treatment preoperatively. This animal was injected first on the sixty-fifth postoperative day, and gave at successive observations the values of Q_* , 1.81 (pre-injection), 1.88, 1.86, 1.85, 1.86, 1.82, 1.76, and (next morning) 1.55. A second injection was given on the one hundred and eighth postoperative day with like results. These experiments indicate the pancreas as the source of the normal response. However, they do not exclude the possibility that a tolerance for the drug is developed, nor that the supply of amylase or its precursors is so depleted by the first response that another of the same magnitude is rendered impossible until after the lapse of a suitable period for recovery. Accordingly, one dog (No. 7) was reinjected after a lapse of four days, and two others (Nos. 3 and 8) after

a week. The results are given in Chart 5 with those of the initial injection included for comparison.

In each instance the second response was less than the first, but these differences are not nearly so striking as that for Dog 2 with pancreatectomy intervening (Chart 4).

Although the pancreas seems definitely implicated in the response, these data furnish no insight as to the relative importance of altered acinar secretion and duct spasm, the two effects of parasympathetic stimulation reported by Anrep^{20, 21} and Korovitsky.²² We sought in the experiments which follow to bring evidence to bear on this question, and to indicate by functional means

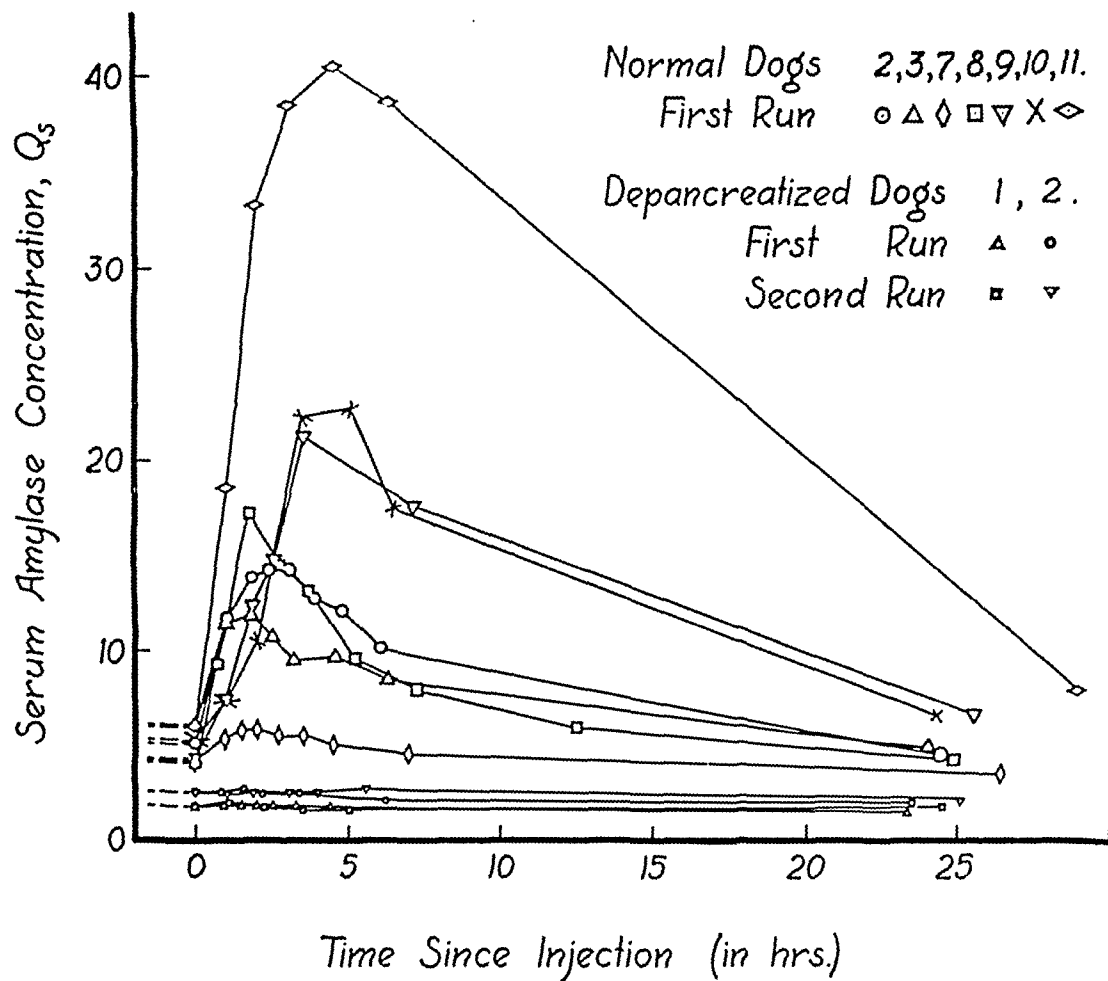


CHART 4.—Comparative response of normal and of depancreatized dogs to standard injection of acetyl β -methylcholine and eserine.

the progress of acinar atrophy even when the serum amylase concentration is not suggestive of abnormality. To this end, two animals (Nos. 10 and 11), which had already been injected once under the standard conditions, were subjected a few days later to ligation of the pancreatic ducts. In each instance portions of the major and minor ducts were excised between ligatures to insure complete and persistent obstruction. After the operation, pancreatin was included in the diet. The serum amylase concentration was observed frequently throughout a period of several weeks, and the response to the standard dose of acetyl β -methylcholine and eserine was observed at various times (Chart 6).

It may be seen that in each dog ligation initiated a characteristic rise in Q_s . Dog II was reinjected two days after operation, and the further vig-

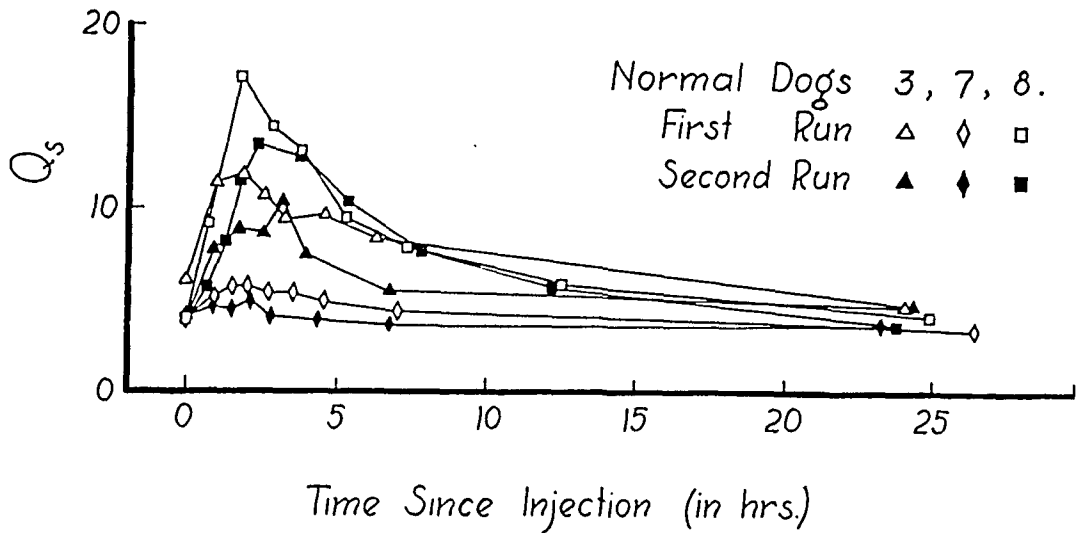


CHART 5.—Comparative response of normal dogs to two separate injections within a week of a standard dose of acetyl β -methylcholine and eserine.

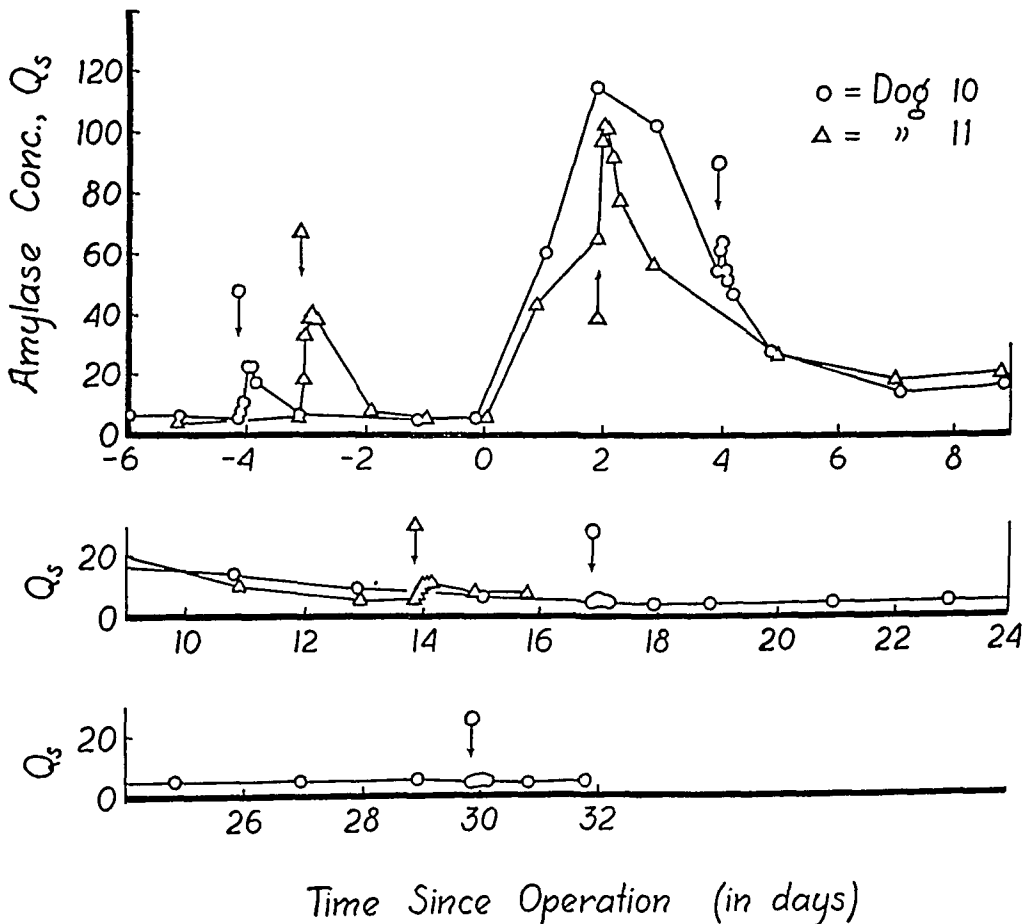


CHART 6.—Response to standard injection of acetyl β -methylcholine and eserine at various times (indicated by arrow) before and after ligation of the pancreatic ducts.

orous response indicates an action on the acinar secretory mechanism, since spasm of already ligated ducts could hardly produce an effect of such mag-

nitude. The reaction of Dog 10 to injection on the fourth postoperative day confirms this, and indicates furthermore that the acinar tissue can still respond after the serum amylase concentration has begun to decline. These effects are in striking contrast with those observed a fortnight or more after duct ligation; and, indeed, it would appear that the response diminishes concomitantly with the progress of acinar atrophy. Thirty days after operation the value of Q_s in Dog 10 was 4.40, approximately the normal median. This was just before a standard administration of acetyl β -methylcholine, following which the values successively obtained were 4.67, 4.89, 4.90, 5.11, 4.72, and (next morning) 4.47.

At postmortem examination of Dogs 10 and 11, the pancreas in each case was pale, shrunken and firm. Microscopic examination revealed diffuse fibrosis and acinar atrophy, more advanced in the case of Dog 10.

DISCUSSION.—In experiments in which animals were repeatedly injected with acetyl β -methylcholine and eserine in order to study immediate and remote effects of various operative procedures, it seemed that striking decreases in response could hardly be attributed solely to developed tolerance. As is well known, such medication induces many effects other than that upon serum amylase concentration; clinically striking among which are increased salivation and evidences of gastro-intestinal hyperactivity, such as borborygmi, retching, vomiting and defecation. Judged by the severity of these reactions, the dogs do not appear to develop an appreciable tolerance; but, after one injection, depletion of amylase supplies in the pancreas may temporarily diminish its ability to respond again. The results of experiments wherein normal dogs were injected twice within a week (Chart 5) may be interpreted in this way, but not with great confidence on the basis of these data alone.³⁴ In any event, considerably greater differences were found in the tests interpreted to indicate pancreatic acinar hypofunction, and in these instances much longer periods were permitted for recovery from preceding injections. Such was the case with the animals whose ducts were ligated, the response to the drug injection a fortnight or more after operation being strikingly less than that observed preoperatively. The simple measurement of Q_s at these same times exhibited little difference, and gave no indication of the extensive postoperative atrophy. Supply of serum amylase by extra-pancreatic sources, whatever these may be, seems unaffected by administration of acetyl β -methylcholine and eserine, and this test furnishes a far more specific indication of pancreatic acinar hypofunction than does the simple measurement of serum amylase concentration. Response to the drug appears to result at least in part from increased rate of release of amylase by the acinar tissue. However, our data do not indicate whether or not the rate of amylase formation is affected, nor how important the rôle of duct spasm may be in production of the response observed in normal animals.

We have called attention to the sporadic occurrence in presumably normal dogs of extensive spontaneous rises in Q_s ; and have indicated that these are referable to the pancreas, since they were not observed in depancreatized

animals. It may be supposed, in the light of our experience with acetyl β -methylcholine, that these spontaneous perturbations reflect merely functional disturbances attributable to parasympathetic hyperactivity. However, we were able to demonstrate that in at least one instance there was associated structural alteration. This was the case of Dog 4, whose pancreas was removed at a time when the serum amylase concentration had risen spontaneously to an extraordinarily high value. The sharp drop in Q_s thereafter definitely implicated the pancreas; and, although the removed gland appeared normal in gross, histologic examination revealed minute necrotic lesions. It would be rash to assume on the basis of this single observation that such pathologic changes are the usual cause of extensive spontaneous increase in Q_s , but we wish to suggest that mild focal pancreatitis, transient and escaping recognition, may occur fairly frequently in the dog. The observed lesions resemble those found in human cases of acute interstitial pancreatitis recently reported by Elman,^{35, 36} who noted in several cases so diagnosed a transient elevation of serum amylase concentration. In the patients discussed by Elman abdominal pain was a striking feature, and was characteristically associated with gross swelling or induration of the pancreas. A milder form of this disease, with no conspicuous symptoms, might well account for occasional high values of serum amylolytic potency observed in presumably normal individuals. In 1931, Elman¹⁹ was inclined to attribute such observations made by himself, McCaughan and their co-workers to salivary contamination in pipette technic. However, we³⁷ have occasionally observed in presumably normal persons values of Q_s about twice the normal mean, under conditions wherein the possibility of salivary contamination could be confidently excluded. The rise in Q_s after a short period of latency which occurred in each of two dogs subjected to formation of gastric pouch is interesting in that Popper³⁸ has reported similar effects, which he ascribed to transient pancreatitis, after gastric resection in humans. A similar explanation might apply to our dogs.

The results obtained with injection of acetyl β -methylcholine in dogs suggest the application of similar technics to the diagnosis of human pancreatic disease. A few preliminary experiments were made in which moderate doses were injected, unaccompanied by eserine. In some persons a rise in serum amylase concentration ensued, but our observations are too fragmentary to warrant discussion of their significance. It would seem the part of discretion to administer the drug only to patients in whom a diagnosis of acute pancreatitis may be confidently excluded.

SUMMARY

(1) The concentration of serum amylase, Q_s , of normal dogs and those subjected to various experimental procedures was measured by a precise viscosimetric method.

(2) After pancreatectomy there was a sharp decline in Q_s to about one-half the normal median value and no return even after several months.

(3) Occasionally, in presumably normal animals there were extensive spontaneous rises in Q_s , which appeared definitely attributable to the pancreas.

(4) The subcutaneous injection of acetyl β -methylcholine chloride with eserine sulphate in normal dogs initiated a prompt rise in Q_s which attained a maximum in a few hours and then gradually subsided.

(5) The lack of such response in depancreatized dogs similarly treated indicates that supply of serum amylase from extrapancreatic sources was not appreciably affected by these drugs.

(6) Following ligation of the pancreatic ducts a vigorous serum amylase response to the drugs could still be obtained for several days, but not after the lapse of several weeks, when extensive acinar atrophy had occurred.

(7) Paucity of response in Q_s to injection of acetyl β -methylcholine with eserine appears to furnish an indication of subnormal pancreatic acinar functional ability.

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- ²⁷ An unqualified statement that a given specimen of dog serum contains ten times as much amylase as one of human serum is therefore meaningless.
- ²⁸ This unit is approximately 1.63 times that employed by Johnson and Wies.³

- ²⁹ A fiber so small as to be almost imperceptible may introduce a gross error in viscosimetry. We avoid, therefore, the use of cotton plugs in any apparatus associated with this technic. With care, salivary contamination of solutions may be avoided without the use of plugged pipettes.
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- ³³ We are indebted to Drs. C. G. Burn of the Dept. of Pathology and T. W. Workman (D.V.M.) of the Dept. of Bacteriology and Immunology, who reviewed the microscopic preparations in this case.
- ³⁴ As a basis of comparison in these experiments the increments in Q_s for the first two hours after injection may be taken. The ratio, R , of this response to the second injection relative to that for the first was 0.52 for the four day interval, and 0.91 and 0.70 for the seven day intervals. Disregarding the differences in these intervals, $\log R$ may be submitted to the *t-test* described by R. A. Fisher (Statistical Methods for Research Workers, Oliver and Boyd, London). On this basis $P = 0.15$, a considerable margin of doubt as to significance.
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INGUINAL HERNIA

A REPORT OF 1,600 OPERATIONS

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THIS is a review of 1,600 consecutive operations for inguinal hernia performed at the Henry Ford Hospital during the ten year period 1920-1929.

The investigation was undertaken in an endeavor to determine, as accurately as possible, the end-results of the various operative procedures and to arrive at a definite figure for the recurrent rate. The method adopted was to arrange the cases into two groups—traced, and untraced. An arbitrary period for division between traced and untraced had to be fixed. Some of the published statistics are based on a six month follow up on the assumption that most recurrences appear within six months of operation. A suspicion was entertained that this period was too short; accordingly, a two year follow up period was chosen. Thus all patients who were not followed for at least two years subsequent to operation were listed with the untraced group. When the recall was completed and the records reviewed it was found that there were 800 operations in the traced, and 800 in the untraced group. The recall was effective in only 50 per cent of cases owing to the majority of the patients being drawn from the industrial population.

Final review of the records showed that there were 614 patients upon whom 800 inguinal hernia operations had been performed in the traced group and 633 patients upon whom the same number of operations had been performed in the untraced group. Except for the purpose of estimating the recurrent rate and the length of time followed, both groups are considered for statistical purposes, because it was believed valuable facts might be deduced from consideration of both groups as a whole.

Sex.—Inguinal hernia in the female is relatively infrequent since only 27 or slightly more than 1 per cent of the 1,600 operations were performed upon women as compared with 1,573 or 98.9 per cent upon males (Table I). Increased occupational hazards as well as developmental differences probably account for the predominance of the condition in the male.

TABLE I

	SEX	
	Number of Patients	Percentage
Male.....	1,573	98.9
Female.....	27	1.1

Age.—The youngest patient was a three week old infant with a strangulated hernia and the oldest a man of 89 with the same condition. Over 80 per cent. of the series falls in the third, fourth and fifth decades, *i.e.*,

between the ages of 21 and 50, the period of greatest physical activity (Table II).

TABLE II

Age Group	AGE		Percentage
	Decade	Number of Patients	
1- 10	1	51	3.2
11- 20	2	65	4.1
21- 30	3	402	25.1
31- 40	4	493	30.7
41- 50	5	392	24.5
51- 60	6	129	8.1
61- 70	7	60	3.8
71- 80	8	6	0.4
81- 90	9	2	0.1
91-100	10	0	0.0

Obesity.—Of the 1,600 operations performed for inguinal hernia, 114 or 7.1 per cent were recorded as having been performed upon obese individuals. The presence of excess fat in the subcutaneous and extraperitoneal tissues makes the operation technically more difficult, lengthens the operating time and increases the risk of infection. That these factors have an adverse effect upon the recurrence rate is indicated by the observation that of the 66 recurrences seven or 10.5 per cent occurred in overweight patients. Further incriminating evidence is introduced by pointing out that in the 800 operations in the traced group 58 were done on fat persons with seven recurrences, a percentage of 12.1, while the recurrent rate for the whole group was 8.25 per cent.

Occupation.—Occupations which entailed heavy lifting were engaged in by 1,320 or 82.5 per cent of the whole series while only 280 or 17.5 per cent pursued a sedentary type of work. These figures draw attention to the importance of trauma in etiology of hernia. Further emphasis is laid on this point by noting that of the 66 recurrences recorded 59 or 90 per cent occurred in patients who gained their living by hard labor (Table III).

TABLE III

OCCUPATION

	Number of Patients	Percentage	Recurred	Percentage
Hard labor.....	1,320	82.5	59	90
Sedentary.....	280	17.5	7	10
Totals.....	1,600	100.0	66	100

Trauma.—A definite history of injury was obtained 994 times or 62.1 per cent of the total number. It is interesting to conjecture the exact rôle played by trauma. A detailed interrogation regarding the accident will usually elicit the information that the foot on the involved side slipped while engaged in lifting a heavy object or that the individual was suddenly called upon to support a heavy weight without having time to brace himself. On

the other hand, severe strain with the feet firmly braced does not appear to be a factor in initiating the train of events which results in the appearance of a rupture. When the foot slips the thigh is flexed with consequent release of the tension on the aponeurosis of the external oblique muscle. In this manner the buttressing effect of the aponeurosis is removed and the internal inguinal ring rendered more vulnerable by being partially unguarded. Increased intra-abdominal pressure exerted against an internal ring already weakened by the presence of a preformed sac, and now lacking its outer guard, creates an ideal situation for the entrance of abdominal contents into the sac and the clinical appearance of a hernia. This suggests the importance of utilizing the external oblique aponeurosis in hernial repair.

TABLE IV
DURATION OF HERNIA BEFORE OPERATION

	No. of Patients	Percentage	No. of Recurrences	Percentage
1 day-1 week.....	74	4.6	1	1.5
1 week-1 month.....	236	14.8	11	16.6
1 month-6 months.....	468	29.3	15	23.0
6 months-1 year.....	196	12.2	11	16.6
1 year-5 years.....	335	20.9	14	21.3
5 plus years.....	219	13.7	10	15.0
Congenital.....	72	4.5	4	6.0
Totals.....	1,600	100.0	66	100.0

It will be noticed from a study of the figures in Table IV that the trend is toward early operation. Almost one-half of the patients were operated upon within six months of the development of the hernia; over 60 per cent within a year of onset, and 30 per cent within a month of its appearance. Those waiting over five years represented only 13.7 per cent of the total group. The time interval between the occurrence of the hernia and operation had no appreciable bearing on the recurrence rate. It will be seen that the figures in the percentage columns in Table IV closely approximate each other.

Truss.—Before operation 374 or 23.4 per cent of the herniae were retained by a truss. It has been stated that the wearing of a truss tends to weaken the tissue of the inguinal region by its continuous pressure, thus making repair less satisfactory. The statistics from this compilation do not bear out this contention, because of the 66 recurrences only 12 or 18.2 per cent had worn trusses.

Incarceration.—The operation for strangulated hernia today is a relatively infrequent surgical emergency. In this review only 22 or 1.4 per cent of the 1,600 operations were performed for incarcerated herniae and of this number only one required intestinal resection. This is an index of surgical progress and stands in marked contrast to the early publications on this subject, when strangulation was practically the only indication for operation.

The total number of herniae occurring on the right side exceeded that on the left in the ratio of 6 to 5. The difference between the right and left

side is even greater when the cases involving both sides are excluded and single herniae alone are considered. Here it is found that the ratio is 4 to 3. Recurrence, however, was found to be much more common on the left side since of the 66 recurrences 38 or 57.6 per cent followed left hernioplasties and 28 or 42.4 per cent followed right hernioplasties, thus reversing the 4 to 3 ratio. The same observation may be brought out in another way by consideration of the fact that there were in the traced group 420 right sided herniae with 38 recurrences, a rate of 6.7 per cent, and 380 left sided herniae with 28 recurrences, a rate of 10 per cent. Bilateral herniae were found in 353 or 28.3 per cent of the 1,247 patients in the series (Table V).

TABLE V

SIDE INVOLVED

	No. of Herniae	Percentage	No. of Recurrences	Percentage Each Side
Right.....	872	54.5	28	42.4
Left.....	728	45.5	38	57.6
Totals.....	1,600	100.0	66	100.0

	No. of Patients	Percentage
Right side alone.....	519	41.6
Left side alone.....	375	30.1
Bilateral.....	353	28.3
Totals.....	1,247	100.0

	Operations Traced	Recurrence	Percentage
Right.....	420	28	6.7
Left.....	380	38	10.0

Anesthetic.—An examination of the anesthetic charts of these patients reveals the great change in anesthetic methods that took place during the decade 1920–1929. At the beginning of this period open ether was used in nearly all cases. Then, with the advent of gas anesthesia, nitrous oxide and ether were employed for a short time. This was soon supplanted by ethylene, which was used in over 60 per cent of the cases, either alone or in combination with ether. Spinal anesthesia was just coming into vogue at the close of this period as is indicated by its use in only 8 per cent of the operations. These figures are now reversed, for over 90 per cent of the present day herniotomies at this hospital are done under spinal anesthesia. The perfect relaxation resulting from this anesthetic procedure makes it easy to obtain a high ligation of the sac, since the omentum and intestines are at rest and not continuously pushing up into the wound as is the tendency when inhalation anesthesia is employed. Furthermore, the identification and repair of the transversalis fascia is rendered less difficult because of the ease with which retraction of the transverse muscles is obtained. Spinal anesthesia is definitely contra-indicated in the poor risk patient and in our experience it has not reduced the incidence of postoperative respiratory complications.

Local anesthesia was infrequently used, only 36 or 2.3 per cent of the total operations having been done with novocain. It was employed with advantage in patients in whom a general or spinal anesthetic was contra-indicated because of hypertension, respiratory infection or poor general condition associated with neglected strangulation.

TABLE VI
ANESTHETIC

	No. of Operations	Percentage
Ethylene and ether.....	524	32.8
Ether.....	475	29.7
Ethylene.....	359	22.4
Spinal.....	129	8.0
Nitrous oxide—ether.....	77	4.8
Local.....	36	2.3

Classification.—Only 15.7 per cent of the herniae were direct. Indirect inguinal herniae predominated over the direct variety in a ratio of greater than 5 to 1. In the traced group of cases there were 154 direct herniae of which 18 or 11.6 per cent recurred, while out of the 646 indirect herniae in the same group 48 or 7.4 per cent recurred. Thus the probability of recurrence after operation is more than 50 per cent greater in a direct than in an indirect hernia. The saddle-bag or pantaloons type of hernia was found in 126 or 7.9 per cent of the total operations. This special classification was included with the direct herniae, since protrusion of the medial part of the sac through Hesselbach's triangle demands plastic repair of the area. Failure to recognize the presence of a double sac is one of the principal causes of recurrence after operation. In this review seven or 10.6 per cent of the 66 recurrences followed repair of saddle-bag herniae. This is practically the same figure as obtained in simple direct hernia.

Sliding hernia, where a portion of the sac was formed by the peritoneum covering the sigmoid colon, was noted in 53 or 3.3 per cent of the total operations. In spite of the fact that a high closure of the sac could not be made, the recurrence rate was not adversely affected since only one or 1.5 per cent of the total recurrences followed repair of a sliding hernia (Table VII). It was not found necessary to resort to intra-abdominal fixation of the pelvic colon or to the Moschowitz operation in any of these cases.

Size of Hernial Sac.—A moderate sized hernial sac, that is one which occupies the inguinal canal throughout its extent but does not enter the scrotum, was described in 1,040 or 65 per cent of the total operations. Large complete scrotal sacs and small sacs were found in about equal numbers, comprising the remaining 35 per cent in the proportion of 17.3 and 17.7 per cent, respectively. The size of the hernial sac had little if any bearing on the percentage of recurrence, inasmuch as there is not a great variation of figures in the percentage columns in Table VIII. This shows that the proportionate rate of the various sized herniae for the whole group and for the recurrences is practically the same. These figures fail to substantiate the

TABLE VII
CLASSIFICATION OF HERNIAE

		Total No. of Herniae		Percentage	
Indirect.....		1,349		84.3	
Direct.....		251		15.7	
Totals.....		1,600		100.0	
		No. of Cases	Percentage	Recurred	Percentage
Saddle-bag.....	126	7.9	7	10.6	
Sliding.....	53	3.3	1	1.5	
		Traced Herniae		Recurrent	Percentage
Indirect.....		646		48	7.4
Direct.....		154		18	11.6
Totals.....		800		66	8.25

claim that large herniae are more difficult to cure. The implied indictment of small herniae may be explained on the ground that the surgeon may be less careful with the repair when the sac is small.

TABLE VIII

SIZE OF THE HERNIAL SAC

Size	No. of Patients	Percentage	Recurred	Percentage
Moderate.....	1,040	65.0	41	62.1
Small.....	284	17.7	14	21.2
Large.....	276	17.3	11	16.7
Totals.....	1,600	100.0	66	100.0

Method of Closing the Sac.—The most popular method of closing the hernial sac was by twisting the neck and then doubly transfixing it with heavy silk sutures. This was done in 762 or 46.4 per cent of the total operations with eminently satisfactory results. It gives the highest possible closure of the sac and when completed it presents, on the abdominal surface, a firm buttress of tissue instead of the dimple shown after alternative methods of closure. Unfortunately, it can be utilized only when the neck of the sac is small or of moderate size. Next in choice was the straight continuous suture, similar to the suturing of the peritoneum after a laparotomy. It was made use of in 335 cases or 21 per cent of the total. Its special adaptation is in the closure of large direct sacs where the proximity of the bladder renders twisting of the neck of the sac inadvisable and when a satisfactory closure cannot be accomplished with the purse string suture because of excess preperitoneal fat. The purse string suture, a valuable method of closing the neck of the sac, was used in 253 or 16 per cent of the cases. Next to twisting, it accomplishes the highest closure and when reinforced by a second similar suture, an admirable protective pad is formed at the internal ring. It can even be used in large hernial sacs encroaching on the bladder if the

preperitoneal fat is not too abundant. Transfixion of the neck of the sac is useful only in recent herniae with long narrow necked sacs. It was employed in 197 or 12.3 per cent of the series. The sac was not opened in 53 cases or 3.3 per cent of the operations. Failure to open the peritoneal cavity during the course of a hernial operation should be considered as a technical error on the part of the surgeon. A potential indirect sac can always be found at the internal ring if a careful search is made. This sac should invariably be opened and the inguinal region explored from within. In this manner it is frequently possible to demonstrate the presence of a small direct or even a femoral hernia, previously overlooked. In the cases under review there were 24 in the traced group where the sacs were not opened, and of these two recurred. The obvious inference is that the sacs were overlooked by the surgeons at the time of operation, a mistake that would not have been made had the peritoneal cavity been entered at the internal ring.

Reference to Table IX shows the relative value of the different methods of closing the sac with reference to the recurrent rate. This suggests that transfixion and purse string sutures give the best and straight sutures the poorest results. In considering the merits it should be remembered that transfixion is used only in small herniae and that straight suture is made use of in large direct hernial sacs. Thus a direct comparison is not justifiable since the recurrence rate might be expected to be high in cases closed with straight suture and low in sacs closed by transfixion. Furthermore, the good showing of the twisting method must be due in part at least to the fact that only small and moderate sized hernial sacs are suitable for that technic. The record of the purse string suture is excellent taking into consideration its wide adaptability.

TABLE IX

METHOD OF CLOSING THE SAC				
Method	No. of Herniae	Percentage	Recurred	Percentage
Twisting.....	762	47.4	27	40.9
Straight suture.....	335	21.0	20	30.3
Purse string.....	253	16.0	11	16.7
Transfixing.....	197	12.3	6	9.1
Not opened.....	53	3.3	2	3.0
Totals.....	1,600	100.0	66	100.0

Choice of Operation.—The Halsted operation was performed 1,386 times or 86.6 per cent of the total operations, and the Bassini operation was performed on 214 occasions or 13.4 per cent of the total. The Halsted technic as followed in this hospital is that described by Halsted in his later publications on hernia. Essentially it is the same as the Ferguson operation, for in both, the structures forming the spermatic cord are buried beneath the internal oblique and transversalis muscles. The Halsted operation in addition calls for a high ligation of the sac, utilizes the cremaster muscle and fascia

in the repair and emphasizes imbrication of the aponeurosis of the external oblique muscle. It provides better support for the internal ring than any other type of operation yet devised. For this reason it is ideal for the repair of indirect herniae where the defect is confined to the internal ring. The necessity for providing a path of exit for the cord at the pubic spine renders this technic unsuitable in the treatment of direct herniae because it fails to supply additional support to Hesselbach's triangle at its most vulnerable spot. This region at the medial attachment of Poupart's ligament, and in close proximity to the pubic spine, is the common site of recurrent direct herniae. Adequate repair of this area can be carried out only when the cord is transplanted above the internal oblique and transversalis muscles, as in the original Bassini operation. The reinforcement may be augmented by imbricating the external oblique aponeurosis under the cord as originally done by Halsted and as recently advocated by Stetten. This modification was employed in only 11 or 5 per cent of the 214 Bassini operations.

The Bassini technic also has its weak point and this, too, is associated with the emergence of the cord. Here, the region of the internal ring is inadequately protected, a deficiency that may be obviated, to some extent, by placing a suture external to the internal ring, due care being taken not to include the ilio-inguinal nerve when inserting the needle. The problem of hernial repair is thus a question of what to do with the cord. If technical errors are eliminated, recurrences after the use of the Bassini technic are found at the internal ring, because of the impossibility of complete closure of this area. On the other hand, when the Halsted operation is correctly employed recurrences are found coming directly through the most medial part of Hesselbach's triangle because of the inadequate support of this region. The question of which operation to use should be decided at the operation table.

After the sac is opened the integrity of the floor of Hesselbach's triangle should be tested by the forefinger of the surgeon applying pressure to the internal surface of this structure. If there is the slightest evidence of weakness the Halsted type of operation is obviously unsuitable. Complete rupture of the transversalis fascia is found in direct herniae, and bulging, to a varying degree, is noted in obese individuals and those past middle life. This group of cases demands the Bassini operation. Closure of the rent in the transversalis fascia or plication of the structure, when it is stretched, is an essential step in the operation. A vertical incision through the anterior rectus sheath just lateral to the attachment of the external oblique aponeurosis will facilitate the closure of Hesselbach's triangle by allowing approximation of the tissues without tension on the sutures. This procedure was applied in 41 or 19.2 per cent of the 214 Bassini operations. The Halsted technic gives satisfactory results in indirect hernia in the young, and when there is no impairment of the musculature or fascia. It has the great advantage of being simple and easier to perform and of minimizing trauma to the cord and other structures. In this analysis the recurrence rate is found

to be approximately the same for both operations. In the traced group there were 127 Bassini operations, with 11 or 8.6 per cent recurrences, and 673 Halsted operations with 55 or 8.3 per cent recurrences. Undoubtedly the recurrence rate for the whole group would have been materially reduced had the cord been transplanted in some of the cases that recurred after the employment of the Halsted operation.

TABLE X
CHOICE OF OPERATION

Type	No. of Patients	Percentage	Operations		Percentage
			Traced	Recurred	
Halsted.....	1,386	88.6	673	55	8.3
Bassini.....	214	13.4	127	11	8.6

Suture Material.—Following the teaching of Halsted, silk was used as the suture material in 1,545 or 96.6 per cent of the operations. In the remaining 3.4 per cent chromic catgut was employed. Silk has many advantages over catgut. The same tensile strength can be obtained with a finer suture, thus reducing the amount of tissue trauma. The suturing can be done with a finer needle thus diminishing the tendency to separation and tearing of the fibers of Poupart's ligament. Furthermore, there is less injury to the nutrient blood vessels of the soft tissues with a corresponding reduction in tissue loss. Unabsorbable sutures keep the tissues in apposition until fibrous tissue repair has organized, thereby diminishing the possibility of separation of important structures when subjected to undue strain during the immediate postoperative period. There is less tissue reaction with silk than with catgut, a fact that may be verified by repairing one side of a bilateral hernia with silk and the other side with catgut. The only valid argument against the use of silk in the repair of herniae is the problem of infection. A certain number of hernial wounds will become infected in spite of every precaution being taken against the introduction of pyogenic organisms. When infection occurs in a wound in which the repair has been made with silk, a real complication presents itself. Healing is delayed for a prolonged period due to the foreign body reaction of the silk. Draining sinuses persist until all the silk sutures in the involved area are discharged. This complication, though not disabling, is annoying to the patient and serves as a constant reminder to the surgeon of his faulty asepsis. The use of silk, therefore, should be restricted to operations performed under ideal conditions. Fascial sutures were not employed in any of the operations in this series.

Bilateral Operations.—Table XII shows that 28.3 per cent of the patients had bilateral operations. This brings up the question of the advisability of doing both sides at one sitting. From an economic viewpoint it is an apparently ideal arrangement for the patient. The idea of one hospitalization, one absence from work and one surgeon's fee has much to commend it but,

as will be shown, both recurrences and complications are much increased in those individuals subjected to bilateral hernia operations. In this series 43 or 65 per cent of the 66 recurrences followed bilateral operations. Thus, while only one-quarter of the patients have both sides repaired, two-thirds of the recurrences were found in this group. The case against bilateral operation is strengthened by noting that out of the total 1,600 operations 83 or 5 per cent were complicated during the postoperative period by sundry conditions and that out of 353 bilateral operations 27 or 7.8 per cent failed

TABLE XI
SUTURE MATERIAL

	No. of Patients	Percentage
Silk.....	1,545	96.6
Catgut.....	55	3.4
Fascial sutures.....	0	0.0
Totals.....	1,600	100.0

to enjoy an uneventful convalescence. This shows an increase of over 50 per cent. The underlying factors contributing to these occurrences are apparent. First, there is the observation that owing to an element of fatigue some surgeons may be a little less thorough when repairing the second side, a situation which is certain to increase the number of recurrences. Moreover, the prolonged anesthetic necessary for a double operation predisposes to an increase in pulmonary complications, and finally, wound infections increase in direct proportion to the length of time consumed in performing the operation.

TABLE XII
BILATERAL OPERATIONS

	No. of Patients	Percentage	Recurrences	Percentage
Single operations.....	894	71.7	23	35
Bilateral operations.....	353	28.3	43	65
Total patients.....	1,247	100.0	66	100
Total operations.....	1,600			

In addition to repair of the hernia, other operations were performed on 166 occasions or in 10.4 per cent of the series. Of these additional operations 105 or 63.3 per cent were for the correction of conditions existing in the genitalia. The appendix was removed in 32 cases or 19.3 per cent of this special group but in only 2 per cent of the total operations (Table XIII). The performance of additional operations had no effect on the recurrence rate. In the traced group of cases there were 82 associated operations with only four recurrences, a percentage of 4.9. This compares favorably with a total recurrence rate of 8.25 per cent.

Additional surgery definitely increased the complications of hernia operations. Wound infection occurred once, or in 3.1 per cent of the 32 patients

who underwent appendectomy at the same time as the herniotomy, while the percentage of infection for all the operations was only 1 per cent. Hydrocele operations appear to occasion the greatest number of complications. It is shown that of the 42 hydrocele operations 9 or 21.4 per cent were complicated by hematmata or testicular swelling and that testicular atrophy resulted in two instances.

TABLE XIII
ASSOCIATED OPERATIONS

	No. of Operations	Percentage
(1) On the genitalia.....	105	63.3
Hydrocele.....	42	
Orchidopexy.....	23	
Varicocele.....	21	
Circumcision.....	14	
Orchidectomy.....	3	
Spermatocele.....	2	
Total.....	105	
(2) Appendectomies.....	32	19.3
Through hernial incision.....	24	
Through separate incision.....	5	
With hysterectomy.....	1	
With salpingo-oophorectomy.....	1	
With cholecystectomy.....	1	
Total.....	32	
(3) Miscellaneous.....	16	
Resection varicose veins.....	4	
Hemorrhoidectomy.....	2	
Salpingo-oophorectomy.....	2	
Intestinal resection.....	2	
Thyroidectomy.....	1	
T and A.....	1	
Adenoidectomy.....	1	
Lipectomy.....	1	
Hysterectomy.....	1	
Vas section.....	1	
Total.....	16	
(4) Other herniae.....	13	
Femoral.....	7	
Umbilical.....	3	
Postoperative ventral.....	2	
Epigastric.....	1	
Total.....	13	
Total associated operations.....	166	

Postoperative Complications.—As is shown in Table XIV, 83 or 5 per cent of the total operations were complicated by a variety of conditions. The

largest group is made up of pulmonary affections which occurred in 33 or 2.7 per cent of the patients. This complication was also the most serious, being responsible for the three deaths which occurred, a mortality rate of 0.24 per cent. One fatality resulted from bronchopneumonia and two from pulmonary embolism. The coughing and sneezing incidental to upper respiratory infection did not appear to have any special bearing on the recurrence rate since of the 66 recurrences only 3 or 4.6 per cent appeared in patients whose postoperative convalescence was complicated by respiratory infections. Wound infection occurred in 16 cases or 1 per cent of the total number. It is usual to place wound infection in the list of causative factors of recurrence of inguinal hernia after operation, however, in this review the case against infection is not pronounced since in only 2 or 3 per cent of the 66 recurrences had wound infection been present.

Hydrocele was noted as occurring after operation 14 times or almost 1 per cent of the total cases. In some instances it followed varicocele operations, in others it was occasioned by trauma to the cord during the course of the operation or by leaving insufficient room for it to emerge. Swelling of the testicle after operation for hernia is evidence of interference with its blood supply. Its importance is due to the fact that swelling may be followed by atrophy of the testicle, a sequela which was observed on 4 or 0.5 per cent of the 800 traced operations. Hematomata in the wound after hernia operation is not of great significance. Complete absorption takes place under conservative treatment. Attempts at evacuation are almost certain to lead to wound infection.

Phlebitis is fortunately a rare complication of herniotomy. It appeared three times or in 0.18 per cent of the total operations. It is an extremely disabling condition because the deep venous circulation is destroyed. When the complication makes its appearance the victim is actually fortunate. Clinical phlebitis means that the patient has escaped the danger of pulmonary embolism, since the clot in the iliac veins has become organized rather than dislodged.

The patient whose operation is complicated runs a little more risk of recurrence than one whose convalescence is uneventful. The difference is not as great as might be expected since of the 800 traced operations 50 or 6.25 per cent had complications and of the 66 recurrences in this group five or 7.6 per cent had complications.

Follow-Up.—Table XV demonstrates the ineffectiveness of the follow-up system. The difficulty in tracing patients is in direct ratio to the time which has elapsed since operation. A fair degree of success was obtained until the fifth year had passed, since over 70 per cent of the traced cases were recalled during this period, and only 30 per cent after this time. The right hand column must be divided by two, in order to arrive at the follow up percentage for each year inasmuch as only one-half of the total operations were traced.

TABLE XIV

COMPLICATIONS FOLLOWING OPERATION

(1)	Pulmonary complications.....	Percentage
	Bronchopneumonia.....	14
	Bronchitis.....	7
	Atelectasis.....	6
	Pulmonary embolism.....	3
	Lobar pneumonia.....	1
	Pulmonary infarct.....	1
	Lung abscess.....	1
		—
		33
		33
		2.7
(2)	Wound infection.....	16
		1.0
(3)	Hydrocele.....	14
(4)	Hematomata.....	13
(5)	Testicular atrophy.....	4
(6)	Phlebitis.....	3
		—
	Total.....	83
		5.0
	Mortality.....	3
		0.24

TABLE XV

FOLLOW-UP

Time Elapsed since Operation	No. of Patients	Percentage
2 years	186	23.2
3 "	140	17.5
4 "	138	17.2
5 "	109	13.6
6 "	67	8.3
7 "	56	7.0
8 "	24	3.0
9 "	4	0.5
10 "	10	1.2
Recurrences	66	8.5
	—	—
	800	100.0

Time of Recurrence.—Table XVI indicates that one-half of the recurrences were observed within one year of operation and that one-third were noted more than two years after operation. The exact time the hernia recurred is often difficult to evaluate. Only where there is an associated trauma can the time be fixed with any degree of certainty. During the first year following operation, when the experience is fresh in the individual's mind, he is likely to be conscious of changes occurring at the operative site, and to seek the advice of the surgeon. As time goes on, however, a recurrence of the hernia may take place without the knowledge of the patient concerned. In these cases the failure of repair is often discovered only when a physical examination is demanded for insurance purposes or for reemployment. It is this fact that lulls the patient into a false sense of security and

causes the surgeon to give a low estimate of his recurrences. The figures in this table denote the futility of attempting to draw inferences regarding the recurrence rate from a short period of observation.

TABLE XVI

TIME OF RECURRENCE

Time	No. of Patients	Percentage
1-12 months.....	33	50.0
1- 2 years.....	11	16.7
2-10 years.....	22	33.3

Recurrences.—There were 66 recurrences out of the 800 cases followed. This gives a recurrent rate of 8.25 per cent for the group. Direct herniae had 50 per cent more recurrences than indirect. The recurrence percentage was practically the same for both the Halsted and the Bassini method of repair. These figures are based on an examination by a competent observer of the operative site in all cases. The minimum time between operation and examination was two years and the maximum ten years. The recurrence rate is not so low as some published statistics but it is based on facts, not estimates. The literature on this subject quotes various figures for the recurrence rate ranging from 1 to 25 per cent. The observation is noteworthy—that the more complete the follow up and the larger the period covered, the greater the number of published recurrences. There can be no doubt that the number of recurrences is greater than the published results would indicate. It is obvious that a definite figure for the recurrence rate is difficult if not actually impossible to determine with any degree of accuracy. The follow up system to be 100 per cent perfect should continue throughout the individual's life. Furthermore, the recurrence rate is modified to some extent by the individual's occupation.

TABLE XVII

RECURRENCES

	Operations Traced	Recurred	Percentage
Total.....	800	66	8.25
Indirect.....	646	48	7.4
Direct.....	154	18	11.6
Halsted repair.....	673	55	8.3
Bassini repair.....	127	11	8.6

Individual Surgeon's Recurrence Record.—The vast majority of these operations were performed by the staff and resident surgeons; only 165 cases, or just over 10 per cent, were done by the assistant resident surgeons and these always under supervision. They are listed with a miscellaneous group designated by the letter "L." It will be seen by reference to Table XVIII that the number of recurrences for this group is less than the average for all the operations. The explanation of this lies in the fact that only straightforward cases were allotted to these surgeons. A study of Table XVIII indicates that while there is a definite variation in the record of indi-

vidual surgeons, the time factor must be taken into account. The contention that the rate of recurrence increases in direct proportion to the time elapsed since operation is very well brought out in this table. Here it is shown the best results were obtained by those surgeons against whom the time factor had not yet been brought into play. When a hernia recurs after operation it can usually be charged as a technical error on the part of the operator. The veracity of this statement is based first on the observation that the recurrence rate among individual surgeons varies considerably and second to the fact that the majority of the recurrences in this compilation which returned for a second operation remain cured. It follows therefore that a technic which cures a recurrent hernia, when operation is admittedly more difficult, would have been equally effective at the first operation. This would indicate that improvement in the results of hernial repair will come not from inventing new operations, but from carefully following certain well defined principles which now yield excellent results when properly applied.

TABLE XVIII
INDIVIDUAL SURGEON'S RECURRENCE RECORD

Arranged in Order of Seniority	As to Number of Traced Operations Performed		As to Percentage of Recurrences	
A	I	124	K	0.0
B	F	121	J	3.3
C	D	82	F	4.3
D	C	74	A	4.4
E	E	73	I	5.6
F	B	70	L	5.7
G	A	68	B	8.5
H	L	67	H	8.6
I	H	35	G	9.5
J	K	35	D	10.0
K	J	30	C	14.8
L	G	21	E	14.9

SUMMARY AND CONCLUSIONS

(1) A follow up period of two years or more was obtained in 800 cases, which showed a recurrence rate of 8.25 per cent.

(2) The recurrence rate for indirect hernia was 7.4 per cent, and for direct hernia 11.6 per cent.

(3) The longer the time which had elapsed since operation, the greater was the number of recurrences.

(4) In indirect herniae, the essential step in the operation is high removal of the sac.

(5) In direct herniae, special attention must be given to repairing and reinforcing the floor of Hesselbach's triangle.

(6) The importance of the repair of the transversalis fascia in the cure of direct herniae is emphasized.

(7) Small herniae in young adults can be cured without transplantation

of the cord but in all direct herniae. In indirect herniae occurring in fat individuals, in those past middle life, and where the sac is large, transplantation of the cord is essential to success.

(8) Bilateral operations show an increase in both complications after operation and in the recurrence rate.

(9) The recurrence of a hernia after an operation is usually the result of a technical error on the part of the surgeon.

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TETANUS*

EXPERIENCE IN THE EPISCOPAL HOSPITAL IN THE PAST 30 YEARS (1905-1935)

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THERE are no reliable statistics concerning the incidence of tetanus in the United States, but we do know that there were 1,253 deaths from the disease in this country in 1933. This corresponds to a death rate of about one per 100,000. Contrast this with two per 1,000 wounded in the Civil War, and two per 10,000 wounded in the World War. These figures show why studies based on cases in civil practice are so limited, although hospitals in some sections of America have had a suprisingly large experience.¹

In the past 30 years there were 56 cases of tetanus admitted to the Episcopal Hospital. Most of these occurred during the warm months, with the peak in July, although none followed injuries from fireworks, and most of them came to us in clusters of two or three. It is, perhaps, well to emphasize the fallacy of attempting to deal too seriously with such a small series by the statistical method. The patients ranged in age from four years to 63, most being between seven and 15. Fifteen (26 per cent) were females, and 41 (74 per cent) males. Of the 56 patients treated, 16 were cured and 40 died (72 per cent). Males showed a 73 per cent mortality (30 out of 41); females 67 per cent (10 of 15).

Table I summarizes the results of the various means of emergency care:

TABLE I
EFFECT OF EMERGENCY TREATMENT (Prophylaxis)

	Cured	Died	Mortality
Number receiving prophylactic serum.....	1	4	80 per cent
Number receiving emergency care.....	5	11	69 per cent
Total number of cases regardless of care.....	16	40	72 per cent

Is one to gather from this that the prophylactic use of tetanus antitoxin is worthless? At first sight this would seem to be the only conclusion to be drawn from the figures showing a higher mortality following the use of prophylactic serum than uninjected cases. However, the larger experience of Army surgeons so absolutely contradicts our own that it almost goes without saying that prophylactic antitoxin is decidedly effective. For example Ashhurst² cites Sanford, who attributed the drop in incidence from two per 1,000 in the Civil War to less than two per 10,000 in the World War to the use of prophylactic serum. He says, "Even allowing for the vast improvement in the mechanical and chemical disinfection of wounds, such a remarkable diminution could never have been secured without the

* Read before the Philadelphia Academy of Surgery, November 4, 1935.

use of antitoxin, especially in view of the highly contaminated nature of the fighting terrain." Ashhurst² cites other foreign authorities summarized below, reaching the conclusion that prophylactic injection of tetanus serum is without doubt, beneficial.

Author	No. Wounded	Serum	Tetanus	No Serum	Tetanus
Bazy.....	200	100	1 (day after)	100	18
Columbina.....	200	198	0	2	2
Walther.....	270	?	1 (day after)	?	18
Fredet.....	12 (German)	0	0	12	6
Fredet.....	? (French)	all	0	0	0
Bruce.....	1,000	0	0	1,000	15-32
Bruce.....	1,000	1,000	2-3		

Bruce,—British army cut off at Kut-el-Amara. Tetanus incidence rose. Aviator dropped serum—incidence fell.

There only remains for discussion how much, where, and when to administer the antitoxin for prophylaxis. A unit of tetanus antitoxin is ten times the least amount necessary to save the life of a 350 Gm. guinea-pig for 96 hours against the official test dose of standard toxin. The test dose is 100 M.L.D. Therefore, in a man weighing 70 Kg. (154 lb.), a comparable dose would be 20 units. However, since man is one of the most susceptible of all animals (horses and Negroes are the most susceptible, chickens the least), and since toxin production in the body increases out of all proportion to the time elapsing since the inoculation, larger doses are used. Fifteen hundred units would seem to be ample. As the toxin travels via the paths of motor nerves (Meyer and Ransom³), it is rational to inject the antitoxin deeply into the injured member, if this is practicable. The time element cannot be overemphasized, also the practice of the emergency surgeon should be condemned in postponing the injection till a more convenient time. Multiple injections after an interval are frequently indicated, as the antitoxin is known to be eliminated in about 12 days. This is especially important in those cases which remain infected or in which secondary interference is necessary, as under those circumstances tetanus spores may suddenly develop into virulent toxin producing organisms. Tetanus following two or more injections is extremely rare.

One, however, should not place too much confidence in prophylactic serum; we have had an unfortunate experience with it, as has the Cook County Hospital.⁴ It is important to realize that one must not develop a false sense of security which might lead to neglect of surgical prophylaxis—for proper care of the primary wound is by far the most important single step in the prophylaxis of this disease. The organism inhabits the intestinal tract of cattle and humans, and is present almost universally in soil, especially cultivated ground. The hospitals in Lancaster, Pa., an agricultural area, report 96 cases during the same 30 year period that the Episcopal Hospital had but 56.⁵

In fact, the rarity of the disease belies the universal distribution of its germ, a fact which has led some observers to search for antibodies in the

serum of normal persons. Factors involving anaerobiosis, such as mechanical exclusion of air, presence of symbiotic aerobes, dead tissue, foreign bodies, *etc.*, must be removed. (Modern prophylactic packages of anti-tetanic serum contain sera against various kinds of gas bacilli). Strong chemicals or caustics should not be applied because they reduce the vitality of the tissue, nor are oxidizing agents of the slightest value, probably because of the great reducing power of the tissues. Tincture of iodine painted in the vicinity of the wound is probably beneficial because of the induced hyperemia, not because it is a chemical antiseptic. Wounds of the lower extremity, puncture wounds, splinters, burns, compound fracture, and gunshot or blank cartridge wounds require special care; and vaccinations, in former years, showed a rather high incidence of tetanus. Coal mine injuries, on the other hand, are said to be very unlikely to be followed by tetanus, although Becker⁶ reports its occurrence in miners after injury with coal. It may be noted in our own series, a fact which is stressed by Taylor,⁷ namely, that in acute tetanus apparently innocent or clean wounds are rarely really clean, but that foreign bodies and necrotic tissue are often found when such wounds are opened. Perhaps that is why trivial injuries, such as punctures, abrasions, vaccinations, *etc.*, have a worse record than serious ones, as compound fractures and traumatic amputations in our series. In other words, severe wounds receive more radical primary care, far and away the most important single item in the prevention of tetanus.

In concluding this discussion of tetanus prophylaxis, it should be noted that the shortcomings of the injection of antitoxin have stimulated a search for a biologic method devoid of the inconveniences and dangers of serum, with the result that active immunization of humans with tetanus toxoid bids fair to develop into a practical method of immunization. Sneath,⁸ and Bergey⁹ point out that tetanus toxoid, made by treating the toxin with formalin, may be used to raise the titer of antibodies in human serum to significant amounts when injected in suitable quantities at proper intervals. However, these antibodies disappear in about a year, but may be called forth again very rapidly whenever necessary by a single subsequent injection of toxoid. Bergey suggests that persons exposed to a tetanus hazard be prepared in advance by three inoculations of tetanus toxoid. Then, in the event of a probable later need for rapid prophylaxis, a single dose of the toxoid will be enough to induce immunity. A similar method, using the inhalation route instead of the hypodermic, has been tried, but has not yet emerged from the experimental stage.¹⁰

Treatment.—The treatment of tetanus resolves itself into four phases: (1) Care of the focus. (2) Treatment of the intoxication. (3) Symptomatic treatment. (4) Maintenance of nutrition and fluid balance.

Care of the focus is placed first because to speak of the specific treatment without mentioning surgical treatment would be taking the risk of creating a false impression. Taylor lays great stress upon removal of original focus. He treats a case of acute tetanus as an emergency operation. In our own experience we have had nothing like the brilliant results which Taylor

claims for this method. For example, in four infected wounds excised in our own series, two were fatal. Two amputations also resulted fatally. It would seem more rational to treat the symptoms and the toxemia first, but by no means to neglect radical surgical care (preferably excision) of the focus.

Treatment of the intoxication is quite unsatisfactory. Tetanus toxin travels via motor nerves, probably along the axis cylinders, though also possibly through the perineural lymphatics, to the central nervous system (Meyer and Ransom³). Wassermann and his associates have shown that central nervous tissue has the greatest affinity for the poison, and that motor nerves possess this same power of neutralizing the toxin, but to a less degree, as the distance from the central nervous system increases. The poison circulates in the blood, and possibly in the lymph, but it is extracted from there by motor end-plates throughout the body, thus explaining why trismus is often the first sign (short pathway from blood via motor nerves to brain), even when the focus is at some distant point, as in the foot. Toxin ununited to nerve tissue is the only portion which antitoxin can affect. Unfortunately, it is only bound, unreachable toxin, which causes symptoms.

Other factors influencing the outcome of serum treatment are (1) the incubation period (long incubations are less dangerous than short ones), (2) severity of the disease, (3) the promptness with which treatment is instituted. (In our series, incubation periods of seven days or less (minimum four days) gave an 80 per cent mortality; those of 14 days or longer, maximum 32 days, a 67 per cent mortality.) Our series shows no decline in mortality rate as the years go by, in spite of ever increasing amounts of antitoxin, nor does one method of injection seem to be of more benefit than another. Nevertheless, until there is positive evidence to the contrary, it is my opinion that antitoxin should be used in treatment because it is rational.

There would seem to be no good reason for piling up tremendous doses of this expensive remedy, in spite of the good showing which large doses seem to make in mortality tables. Such figures, one must remember, are usually large because the patient lived long enough to get an accumulation of doses which looms large in the aggregate.

Injection into the nerves was practiced several times in our series, but it would seem like a hopeless task to blockade the huge area involved in small branches, while toxin floats everywhere in the serum to be absorbed by motor end-plates all over the body. Likewise, subcutaneous or intramuscular injections are objectionable because of the huge doses necessary. Fifteen to 25,000 units intravenously are probably equivalent to 100,000 units hypodermically. Intraspinal injection is irrational because of the fixation of the toxin in the substance of the brain, which the spinal fluid does not reach, and which would not be neutralized if it could be reached.

Great care must be used in the intravenous administration of this serum, as it appears that one, and possibly more, of our patients have been killed by it. It should be administered slowly, well diluted in a buffered solution, heated to the proper temperature. In one's haste to give the serum one

should not neglect a most important precaution—that is, the preliminary narcotization of the patient. The stimulus of injecting needles into a patient with this disease might otherwise easily result fatally. General anesthesia is said to make the occurrence of anaphylactic shock impossible, so that this should be remembered in sensitized, desperate cases.

The chief symptom to be combated is muscular rigidity, for it is this which kills the victim as a rule, through exhaustion or asphyxia. Consequently, drugs which cause relaxation are of the utmost importance. Morphine, chloral, and chloroform have been used for many years. Occasionally, other drugs have come into vogue for a while. For example, 25 per cent solution of magnesium sulphate used to be injected intraspinally; but it is nearly certain that two deaths in our series resulted from this procedure. Perhaps some of our most fashionable drugs of the present will some day belong to this discredited group. However, there seems to be a definite place for the use of tribromethanol¹ (Avertin). With this, it is possible to keep the patient narcotized for several days, and to maintain his nutrition and water balance meanwhile by continuous phleboclysis, perhaps with better chance of success than in the years before these measures were available. Mouth feeding is often impossible because of trismus. Injections of a local anesthetic into the masseters has been suggested as a means of overcoming this difficulty.

Whether or not the procedures mentioned above will stand the test of time, the fact remains as true today as when expressed in 1897 by Owens and Porter,¹¹ who conclude as I do now, in the same ungrammatical way, by saying, "An ounce of clean surgery is worth several pounds of serum therapy."

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PERINEAL PROSTATECTOMY

A SURVEY OF 67 CONSECUTIVE CASES

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THIS report includes a study of all perineal operations upon the prostate performed upon public ward patients, for a twelve-month period. It has been stated that a survey including both private and public patients does not give a fair estimate of the value of an operation, inasmuch as many such reports are in a large part composed of statistics on private patients who, as a rule, present themselves for treatment at a much earlier period in the course of their disease, and are consequently usually in much better condition.

Table I shows the diagnoses and operations as carried out in this series of cases. They were consecutive instances occurring in the general ward service, upon whom perineal operative procedures were performed. There were no deaths occurring in this series of cases.

TABLE I

ANALYSIS OF DIAGNOSES AND OPERATIONS IN 67 CASES*

Diagnosis	Operation	Number of Cases
Benign prostatic hypertrophy	Perineal prostatectomy.....	48
Carcinoma of prostate (not extensive)	Radical operation for carcinoma of prostate.....	1
Carcinoma of prostate (extensive)	Conservative perineal prostatectomy.....	9
Prostatic abscess	Perineal incision and drainage.....	4
Abscess of seminal vesicles	Perineal incision and drainage.....	1
Tuberculosis of seminal tract	Radical operation for tuberculosis of seminal tract.....	1
Rupture of membranous urethra	Perineal repair of rupture of urethra.....	1

* Two cases are omitted from this table but are discussed in detail in the body of the paper.

Perineal Prostatectomy for Benign Prostatic Hypertrophy.—Table II shows the age distribution in this group. The youngest patient was 46 years of age and the oldest 81 years. All of these cases were prepared by indwelling urethral catheter drainage, unless troublesome urethritis or a temperature developed. Indwelling catheter, however, was not used in five cases because of the relatively small residual, nor in cases with uninfected urine whose residual was perhaps slightly higher than those that are usually drained, all of whom, however, had good renal function. It was felt that

the danger of infection overbalanced what little advantage might be gained by drainage. In this respect, we are not in accord with those proponents of the suprapubic route, who believe that it is better to have infection present so as to gain, if possible, some degree of immunity prior to prostatectomy. We feel that the drainage afforded by a perineal wound along the path of an anatomic dissection does not offer the possibility of stasis, infection, and absorption that is undoubtedly present in the deep cavity of the suprapubic prostatectomy wound.

In this group there were five patients who had drainage other than by an indwelling urethral catheter prior to operation. Three of these, aged 81, 73 and 68, did not tolerate this procedure, owing to the presence of a pronounced urethritis with accompanying fever. In each of them, urethrostomy was performed through the bulbous urethra, thus allowing the insertion of a catheter through the perineum, directly into the bladder. Following this the temperature soon returned to normal, the patients improved and successfully underwent a perineal prostatectomy. The operation requires only a few minutes and is done under local anesthesia without producing any great discomfort. The objection raised, of course, is that one merely short circuits the urethra and that the deep or prostatic urethra, whose surface is already acutely inflamed, is still irritated by the presence of a catheter. We believe it is popularly thought that the prostatic urethra is usually the area of greatest absorption and therefore the site of the urethral reactions. This fact was recognized in doing this procedure, but we felt that inasmuch as the length of the urethra is greatly diminished by this operation, the drainage is thus greatly facilitated; that the course of the urethra from the perineal incision to the vesical neck is much straighter; also that the perineal opening permits a dependent point of drainage, and therefore the perineal urethrostomy had been efficacious in these cases. Because of their advanced age, and their general condition, a suprapubic cystostomy would have been a major undertaking in these three individuals, whereas perineal urethrostomy gave us our desired result without particularly upsetting the patient. Another important factor in this procedure is that each of the patients was much more comfortable with the perineal catheter than he would have been with the penile catheter.

Suprapubic cystotomy was carried out in one patient (B.U.I. 23525), aged 69. The residual urine was only 50 cc., but there was a large vesical calculus, and symptoms of prostatic obstruction. Rectal examination disclosed a benign prostatic hypertrophy, and cystoscopy revealed the presence of median and lateral obstruction. The phthalein output, although fair, was not what we considered normal, and inasmuch as he did not tolerate urethral catheter drainage, a suprapubic cystotomy was carried out for removal of the calculus, and drainage. Perineal prostatectomy was performed later. The fifth patient (B.U.I. 23684), who was drained otherwise than by an urethral catheter, was 68 years old, and had been in acute retention for about 20 hours. Several attempts had been made elsewhere to catheterize him, all of

which had been unsuccessful. There was marked tenderness in the region of the bulb and perineum, and urethral instrumentation showed that a false passage had evidently been produced. It was therefore deemed wise in this case to carry out suprapubic cystostomy.

Method of Hemostasis in Perineal Prostatectomy.—Hemostasis, in the cases of benign prostatic hypertrophy, was carried out by an approximation of the vesical neck to the prostatic capsule by suture. This method was used in every instance except two. One of these patients (B.U.I. 23956) was 46 years old, with a very small prostate, and hemostasis was obtained by a perineal tube and small iodoform pack. Hemostasis was effected in the second case (B.U.I. 23860) by the use of a Davis bag, after difficulty had been experienced in controlling the bleeding by suture. There were no cases of secondary hemorrhage in this group. An urethral catheter, as well as a perineal tube, was inserted into the bladder at the time of operation, the perineal tube serving as a means of removing clots from the bladder, if necessary. This is usually removed within 24 hours. The urethral catheter is left in varying lengths of time, from 7 to 14 days, according to its being tolerated. One case was closed with the perineal tube alone, as there had been an urethritis previously. The suture technic apparently lowers the incidence of embolism. The explanation for this, we believe, in contradistinction to the cases where a bag or pack is used, is the fact that by means of the suture method only a minimal amount of tissue is compressed and devitalized, so that the resultant necrosis of tissue and extent of thrombosis of the pelvic vessels are materially lessened. In only one case in this group was there suggestion of a pulmonary embolism, as evidenced by chest pain and fever, but this was not substantiated by roentgenologic examination. The absolute control of hemorrhage, with an anatomic restoration of the prostatic bed, as afforded by the suture technic, warrants the use of this procedure.

CASE REPORTS OF INSTANCES WITH DEFINITELY IMPAIRED RENAL FUNCTION

Case 1.—J. G., (B.U.I. 23669), aged 68, was admitted with a history of obstruction to urination for the past two years. During the past six months he had biweekly catheterizations. In the interim he had marked difficulty, voiding frequently, in small amounts and with a very weak stream. Two days before admission, nausea and vomiting occurred, and for the past nine months he had also had severe headaches and attacks of dizziness.

Examination.—Blood pressure, 202/104; temperature, 99.4° F.; pulse, 84; respirations, 20. The patient's clothing was saturated with the odor of urine, he was disoriented, and moderately emaciated. He could pass only a few drops of urine at a time. The bladder was distended to the level of the umbilicus. Rectal examination showed moderate benign prostatic hypertrophy. An urethral catheter was inserted and decompression was carried out over a period of 48 hours. Blood urea 140 mg. per 100 cc. on admission, and the phenolsulphonephthalein determination following decompression showed an excretion of only 3 per cent in the first 30 minutes, with a total of 17 per cent in two hours, the appearance time being eight minutes. This patient had definite cardiovascular disease with a greatly enlarged heart, and marked peripheral arteriosclerosis. He received adequate dosage of digitalis and remained on catheter

drainage for 56 days prior to operation. Blood urea and phthalein excretion showed very little improvement, however, as at the end of this time the blood urea was 84 mg. per 100 cc., the phthalein excretion showed only 10 per cent in the first 30 minutes, with 25 per cent two hour total and six minutes appearance time. However, it was felt that the patient had improved as much as possible, his renal function was stabilized, therefore perineal prostatectomy was undertaken under 50 mg. of novocain, spinal anesthesia. The postoperative course was uneventful. The urethral catheter was well tolerated and was not removed until the twelfth day postoperatively. The perineal wound was well healed on the thirtieth postoperative day. At discharge, blood urea was 80 mg. per 100 cc., and phenolsulphonephthalein test was unchanged. Patient was voiding normally with good control. He appeared clinically well in spite of his poor renal function.

Case 2.—E. W., (B.U.I. 23467), aged 60, gave a history of urinary obstruction for six years. The patient had a dribbling incontinence if he went longer than two hours without voiding. There was definite diminution in the size and force of the urinary stream. Residual urine 325 cc. Blood urea 72 mg. per 100 cc. A phenolsulphonephthalein test showed 16 minutes appearance time, only a trace being excreted in the first 30 minutes, and 21 per cent at the end of two hours and 16 minutes. Blood pressure, 214/116. There was some irregularity in the rhythm of the heart, and definite thickening of the peripheral vessels. Rectal: A moderately enlarged, benign prostate was present. The patient was placed on indwelling urethral catheter drainage, but the blood urea remained between 88 and 116 mg. per 100 cc., and the phthalein excretion did not change. After 44 days it was felt that no further improvement could be gained by continued drainage, and inasmuch as the patient's renal function was apparently stabilized, a perineal prostatectomy was undertaken. The postoperative course was uneventful, with the exception of a *B. proteus* wound infection, which did not cause breakdown of the wound. The patient voided on the seventeenth postoperative day and the wound was completely dry on the twenty-seventh postoperative day. Three and one-half months following operation he stated that he "felt quite well," was voiding only once, and occasionally twice, at night. The blood urea was 68 mg. per 100 cc.

As shown in the tabulation of the age distribution of these cases, nine were in the group of 71 to 75, inclusive, and there was one of 80, and one of 81.

TABLE II

AGE DISTRIBUTION IN THE FORTY-EIGHT CASES OF PROSTATIC HYPERTROPHY

Age Group	46-50	51-55	56-60	61-65	66-70	71-75	76-80	81-85
Number of Cases	1	2	4	10	20	9	1	1

Average age: 66.5 years.

CASE REPORTS OF THE TWO OLDEST PATIENTS

Case 1.—W. M. (B.U.I. 23536), aged 81, gave a history of urinary difficulty of ten years' duration. Five years previously a transurethral procedure was attempted elsewhere, but introduction of the resectoscope was found impossible. Following this, the patient continued frequent voiding of small amounts of urine, accompanied by much straining. There was also a history of auricular flutter over the past 20 years, and this was observed several times during his hospitalization.

Examination.—Temperature, pulse and respirations were normal. Blood pressure, 180/110. The heart showed moderate enlargement and there was marked sclerosis of the peripheral vessels. The bladder was about four finger-breadths above the sym-

physis. Rectal: An enormously enlarged, benign prostate. Indwelling catheter was inserted and decompression carried out. Following this, the patient developed a very severe urethritis and systemic reaction, temperature reaching 103° F. Perineal urethrostomy was performed, which resulted in a return of the temperature to normal, but he appeared quite weak, and although he had a fairly normal phthalein and blood urea, he was allowed to remain on drainage 15 days prior to prostatectomy. During this period the patient had several attacks during which the pulse would reach 160 and he would become slightly dyspneic and apprehensive. Perineal prostatectomy was performed under 50 mg. novocain, spinal anesthesia. The patient had an attack of tachycardia just prior to operation, pulse was 110 at the time of operation, and during operation the blood pressure became imperceptible and intravenous glucose was administered, with effective result. He developed a *B. proteus* wound infection, causing a breakdown of the wound, which greatly retarded his convalescence. Bilateral vasectomy had been performed as routine on practically all of these cases, but, unfortunately, it was not carried out on this individual and he developed a suppurative epididymitis which involved the testis and necessitated orchidectomy. The perineal wound was not healed until the seventy-sixth postoperative day, but on discharge he had very good urinary control and was feeling quite well.

Case 2.—J. C. (B.U.I. 23831), aged 80, was admitted with a history of urinary obstruction and difficulty of four years' duration.

Examination.—Temperature, 104.4° F.; pulse, 146; respirations, 24. Chest showed cardiac enlargement, heart sounds were very poor and irregular. There were a few râles at both bases. Liver was palpable below the costal margin and there was a moderate amount of edema of the lower extremities. Bladder was midway to the umbilicus. Rectal: A moderately enlarged benign prostate. An indwelling catheter was inserted and decompression carried out over a period of 24 hours. After several days' rest in bed, the temperature and pulse returned to normal. The blood urea and phenol-sulphonephthalein excretion showed good kidney function. There being some doubt as to the degree of prostatic obstruction present, the retention catheter was removed, but the patient continued to have difficulty in voiding, and he was found to have 500 cc. residual. Cystoscopy showed lateral and median lobe hypertrophy present, as well as the usual bladder signs of obstruction. Perineal prostatectomy was performed, a small fibrous prostate being removed. Urethral catheter was removed on the sixth postoperative day, the wound remaining dry from the ninth to the twelfth, and then leaked a small amount until the sixteenth postoperative day, after which it healed permanently. At the time of discharge, the patient had very good urinary control, and his general condition was excellent.

The average healing period in cases of perineal prostatectomy for benign prostatic hypertrophy was 24.8 days. This included three cases of severe *B. proteus* wound infection, which caused the wound to break down, in which the healing period was 76, 64, and 56 days, respectively. If these cases are not included, the average period for healing in the remaining 45 cases was 22.1 days.

Radical Operation for Carcinoma of the Prostate.—This procedure was performed on only one patient, E. C. (B.U.I. 23695), aged 53 years, who had suffered from frequency and difficulty of urination for about five months prior to admission. Rectal examination showed very definite carcinoma of the prostate, apparently confined well within the prostatic capsule. Residual urine, 50 cc. Renal function, good. The radical operation was done under spinal anesthesia. The wound had healed at the end of 16 days. On dis-

charge the patient had some slight difficulty in controlling his urine when coughing or sneezing, but on examination five months later, his control was good.

Conservative Perineal Prostatectomy for Extensive Carcinoma of the Prostate.—There were nine cases in this group. The ages varied from 50 to 73 years. Examination in each case disclosed an extensive carcinoma of the prostate in which there was no hope of a radical cure.

Prostatic Abscess.—There were four cases of prostatic abscess and one case of abscess of the seminal vesicles which were drained by the perineal route.

Perineal Repair of Rupture of Urethra.—There was one case (B.U.I. 23627), a steel worker, who received fractures of both lower extremities, pelvis and lumbar vertebrae and a rupture of the membranous urethra at the apex of the prostate, as the result of a fall. An immediate suprapubic cystotomy was performed. Attempts at retrograde catheterization being futile, a perineal intervention had to be postponed until the fractured vertebrae were healed. This, therefore, was done at a later date, with excellent result.

Radical Operation for Tuberculosis of the Seminal Tract.—There was one case (D. S., B.U.I. 22844) in this group, in which nephrectomy had been done previously for tuberculosis. Examination on admission revealed a definite tuberculosis of the epididymis, seminal vesicle and prostate. The perineal wound had healed *per primam* by the end of two weeks.

There was one case (F. N., B.U.I. 23599) of benign prostatic hypertrophy in which, during the course of the perineal dissection, an injury occurred to the rectum. It was thought that this was produced by too forceful posterior retraction. Enucleation had not been begun. The urethrotomy was closed and the rectal injury repaired in two layers. Suprapubic cystostomy was done immediately. At a later date, suprapubic prostatectomy was successfully carried out, without the complication of a perineal urinary fistula. There is another case (H. M., B.U.I. 23832) previously mentioned, in which conservative perineal prostatectomy was attempted but, because of inability to dissect the rectum away from the posterior aspect of the prostate, due to marked carcinomatous involvement, the operation was not completed. The perineal wound was closed, healed *per primam*, and a transurethral resection was carried out later with relief of the obstruction.

SUMMARY

(1) A series of 67 consecutive perineal operations on the prostate, on public ward patients, is reported without a death. This constitutes every case admitted to the public wards, without an exception, receiving a perineal operation, during a period of 12 months.

(2) Suture of the vesical neck to the prostatic capsule decreases morbidity as well as mortality.

(3) The average healing period in cases of perineal prostatectomy for benign hypertrophy was 24.8 days. This included three cases of severe wound infection with a breakdown of the wounds. If these cases are omitted the average period for healing in the remaining 45 cases was 22.1 days.

I am indebted to Dr. Hugh H. Young, whose principles in the management of prostatic lesions have been followed.

RHABDOMYOSARCOMA OF THE NECK

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TUMORS of the spinal muscles of the body wall and extremities are extremely rare. This rarity of tumor formation is probably dependent upon the early differentiation of these structures in the embryo. According to Keith¹ no more new fibers are formed in skeletal muscles after birth, muscular development occurring as a result of the enlargement of the preexisting fibers. Geschickter² states that muscle tumors are not uncommon in the smooth muscles of the genito-urinary organs. In the musculature of the digestive tube, heart and large blood vessels, derived from the splanchnopleura, tumor instances are more unusual. New growths here, however, are neither as rare as in the voluntary skeletal muscles nor as common as in the musculature of the genito-urinary organs. Geschickter has collected a number of cases of muscle tumors from the literature, and has reported those occurring at the Johns Hopkins Hospital. According to Klinge,³ only nine acceptable cases of rhabdomyoma of the body musculature had been described up to 1926. Geschickter reports two additional instances of rhabdomyomata of the voluntary muscles; one of these was in the cervical region of a child and the other was situated in the leg. It is questionable whether the term rhabdomyoma should be used in describing tumors of the voluntary muscles because of their undoubted malignant tendency. Hirsch⁴ reports a case of rhabdomyosarcoma of the spermatic cord and has enumerated the other tumors of this type which have appeared in the literature.

CASE REPORT

Mrs. L. J., white, aged 40, was referred to the Tumor Clinic of the Norton Memorial Infirmary March 28, 1932, by Dr. Lilliard of Lawrenceburg, Ky. For 11 years she had noticed a small swelling on the right side of the neck which had slowly enlarged. For the past four years her gait had been unsteady and her vision failing. She had had no headaches and otherwise the history was unessential. She has two children living and well. There was no history of malignancy in the family except that a cousin died from a cancer of the neck following the removal of a cystic tumor.

Examination.—Patient is a well developed and well nourished white female. The head is normal in size and shape and there is no tenderness over the sinuses. The pupils are equal and react normally to light and accommodation. There is some horizontal nystagmus and no paralysis of the ocular muscles. The ears, nose, mouth and throat are negative.

There is a large tumor mass on the right side of the neck which is firm and not tender. It is approximately 10 by 6 by 5 cm. and is fixed. The skin over it is normal in appearance and is not attached to the tumor. The thyroid is not enlarged. The

lungs are normal, heart regular, good tone, no murmurs. Blood pressure: systolic 130/90. Pulse 80. Abdominal and pelvic examination entirely negative.

The knee jerks are hyperactive and there is a bilateral Babinski. No ankle clonus could be elicited. The abdominal reflexes are present. The Rhomberg is positive, the patient falling towards the right. She walks with a very unsteady gait and with a tendency to fall to the right. There is no disturbance of sensation. Examination of the eyegrounds showed the disks to be pale but distinct in outline. The blood vessels were of normal size and there were no hemorrhages or scars in the retina. Urine negative. Red blood cells, 3,890,000; Hemoglobin, 70 per cent; white blood cells, 7,900. Differential showed a slight increase of neutrophils, otherwise normal.



FIG. 1.—The arrows point to area of third, fourth and fifth cervical vertebra destroyed by the growth.

Röntgenologic Examination by Dr. J. C. Bell.—Stereoscopic films of the cervical spine made in anteroposterior and lateral positions showed defects in the laminae of the third, fourth and fifth cervical vertebrae on the right side and apparently in the articulating facets of these vertebrae as well, especially the third and fourth (Fig. 1). The body of the fifth cervical vertebra does not seem to be quite as dense as the others but no other evidence of destruction is seen. The anterior margin of the first vertebra is peculiar, there being a sharp projection extending up toward the base of the skull. This is very sharply defined and probably is not of clinical significance. There is marked swelling of the soft tissues lateral to the defects in the vertebrae.

It seems evident that there is a destructive lesion arising within the cord or about the ends of the nerve roots. The destruction is probably secondary to this. The defects look as if they were due to pressure rather than to a metastatic growth. The fact that the destruction involves chiefly the right lateral portions of the vertebrae

suggests that it is due to a tumor in the nerve roots or in the structures surrounding the cord rather than to something starting in the cartilage or bone. No other abnormalities are noted.

Operation March 20, 1932. Under ethylene-ether anesthesia a four inch incision was made over the tumor mass on the right side of the neck, exposing the muscles on the posterolateral aspect. The muscles were split and the tumor exposed. It was about the size of an orange, encapsulated and had the appearance of being cystic. The overlying muscles were dissected off the tumor and it was then found that the growth was firmly attached to the third and fourth cervical vertebrae. As the size of the tumor obstructed vision in to the deeper parts of the operative field the tumor was opened and about three ounces of thin brown fluid evacuated. Within the cavity there were several projections about 5 by 25 Mm. having the appearance of muscle tissue. Each projection ended in a blunt conical tip. The remainder of the tumor was solid, and composed about one-half of the entire mass. The tumor itself was then freed down to



FIG. 2.—The cavity contained fluid in which there was much old blood. Numerous bundles of tissue can be seen, one of which is bulbous. These may be attempts at muscle formation.

the cervical vertebrae and it was found that the third, fourth and fifth vertebrae had been eroded and that the tumor mass had grown into the spinal canal. On removing the tumor there was seen what appeared to be tumor tissue within the spinal canal. As much of this as possible was removed and the incision closed with two rows of interrupted sutures. There was some oozing from the depth of the wound which was controlled by a small gauze tampon.

The patient made an excellent operative recovery and left the hospital April 5, 1932. The reflexes were still hyperactive but the patient was walking much better and the gait was steady.

Pathologic Examination by Dr. A. J. Miller: *Gross*.—The specimen consists of a lobulated mass weighing 80 Gm. It is encapsulated. The color is grayish-pink and it has a translucent character. The sectioned surface reveals several cavities, evidently formed by necrosis. They contain dark red, serous fluid that has the characteristics of old blood. On the surface of the tumor and also in the sectioned surface there are bundles of tissue of various sizes and lengths. Some of these have broad ends and long slender tails making them shaped like a tadpole (Fig. 2).

Microscopic.—Sections from various places show a rather uniform structure. There is a parenchyma consisting of very large to small masses of cytoplasm which stains densely with eosin and has longitudinal filaments, but no cross striations. In many areas these large cells contain 8 to 15 nuclei. These cells resemble muscle and are supported by a delicate connective tissue stroma (Fig. 3). Blood vessels are few, but well formed. Mitoses are not seen, but numerous nuclei are apparently in direct division. They are only moderately atypical and vary but little in structure. Invasion cannot be demonstrated. With the aid of the history and the operative report of a lack of limitation, the tumor is classified as of low grade malignancy.

The parenchymal cells are apparently muscle cells, although no cross striae are seen. The multinuclear character would suggest skeletal muscle origin, rather than smooth muscle (Fig. 4); although the latter is possible. There is no evidence of a fetal rest origin, other than the presence of the tumor; therefore, the regional skeletal muscle is suggested as the source.

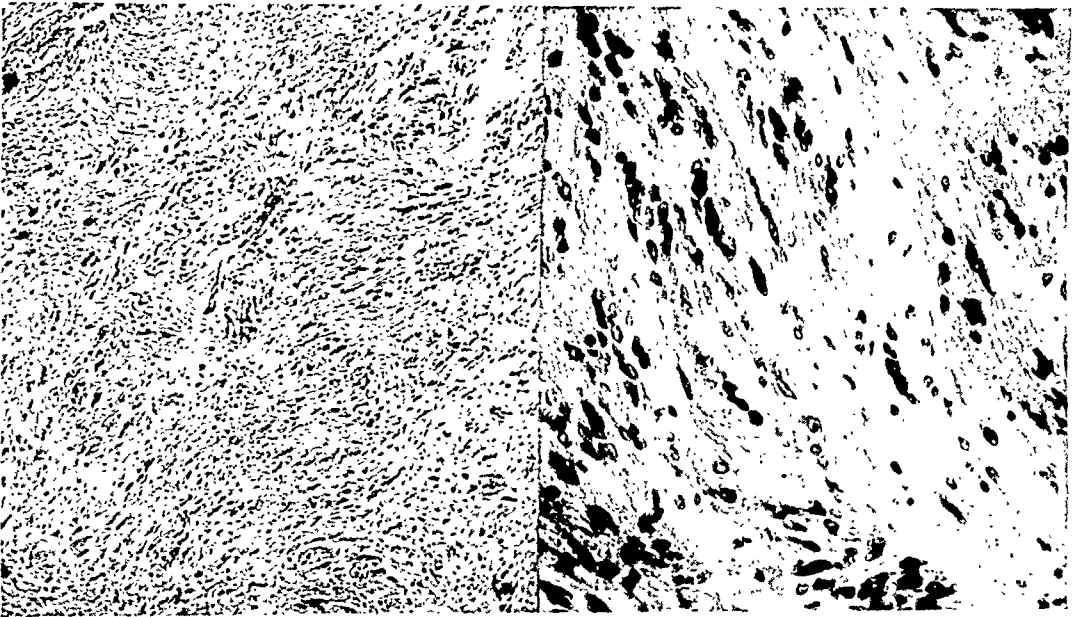


FIG. 3.—There are large masses of eosin staining cytoplasm with multiple nuclei and supported by a delicate connective tissue stroma.

FIG. 4.—There are large, multinucleated masses of cytoplasm with longitudinal fibrils. No cross striation is seen. Between these large cells is a delicate connective tissue stroma. Ph. A. and H. stain.

Sections indicate that the strand-like character of the tumor is the result of an attempt at muscle bundle formation. The expanded ends result from a lack of attachment.

The tumor probably will not metastasize, but be persistent in local recurrence. Resistance to radiation therapy is high for the parenchymal cells, and there are too few blood vessels to expect much response from radiation damage to them. *Interpretation.*—Rhabdomyosarcoma.

The patient was again examined May 1, 1932, because of the appearance of a small tumor at the site of the previous operation. She also complained of some pain in the right shoulder and arm. Pulses were equal and regular. Blood pressure 145/100. Reflexes normal. No Babinski. Rhomberg negative.

She was reoperated upon May 2, 1932. A four inch incision was made along the anterior border of the right sternomastoid muscle. The muscle was retracted outward and the tumor exposed. It was found that the growth was coming out of the cleft on the lateral aspect of the third, fourth and fifth cervical vertebrae. This cleft was

large enough to admit the tip of the finger. The tumor, and as much as possible of that in the spinal canal were removed and 50 mg. of radium, screened with silver, and 1 Mm. of brass, was inserted into the clefts of the cervical vertebrae through which the tumor protruded. The radium was held in place by suture and allowed to remain for five hours. The wound was closed with interrupted stitches.

Pathologic Examination by Dr. A. J. Miller: *Gross*.—Specimen consists of a spherical mass of tissue weighing 4 Gm. It is encapsulated. The color is grayish-pink and slightly translucent. There are a few bundles of tissue, but this character is not so marked as in the previous specimen. There is some old blood pigment.

Microscopic.—The structure is identical with that of the previous specimen. There are, however, fewer large, multinucleated cells, and they are more atypical. This is possibly the result of growth from the less differentiated cells which are more invasive and grow more rapidly. *Interpretation*.—Rhabdomyosarcoma.

The patient made an excellent operative recovery and left the hospital May 7. She was instructed to report in three weeks to Dr. C. D. Enfield for roentgen therapy. This treatment was begun on May 24, 1932, and was continued for six treatment days.

The patient was given two series of roentgen treatments, employing the same physical factors consisting of 160 P.K.V., 8 Ma., 50 cm. distance, $\frac{1}{4}$ Mm. of copper and 1 Mm. of aluminum filtration. In each series the patient was radiated through three fields, the right anterior cervical region, the right lateral cervical, and the posterior cervical areas. The total radiation consisted of one hour to each field, corresponding to 1,320 r units, or a total of 3,960 r for the three fields.

The second series, employing the same factors except that the time was 45 minutes to each field, was started on July 5 and terminated in five treatment days with total radiation of 945 r to each field, or a total of 2,835 r units.

We have seen this patient on several occasions during the past three years. Our last report as to her condition was received from her family doctor August 9, 1935. He states that she is perfectly well, has no headaches, no disturbance in gait and that there has been no sign of any reappearance of the tumor.

Rhabdomyosarcomata are sufficiently rare to warrant adding one more instance to the literature of muscle tumors. This case is of further interest in that it is the only one, of which we have knowledge, that has not succumbed to the disease, although sufficient time has not elapsed to consider it a cure. It is furthermore of interest in that it demonstrates what can be accomplished by intensive radiation of tumors which are usually considered resistant to such forms of therapy.

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THE SURGICAL TREATMENT OF TUMORS OF THE PERIPHERAL NERVES

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THE multiplicity in types of tumors of the peripheral nervous system and the diversity with which these lesions are found in the face, neck, extremities, thorax and abdomen, have given rise to an extensive literature on descriptions of such growths and their proper surgical treatment. The different forms of these neoplasms occurring in widely scattered parts of the body call for operative procedures of great variety, and often tax the surgeon's ingenuity in treating them. There are, however, certain general principles which can be set forth to guide the treatment of nerve tumors as they are attacked at various sites and in the following presentation we briefly review some of the accepted ideas on technical procedures, choice of operations, and postoperative care. We have purposely avoided discussion of the nerve sheath tumors arising in the abdomen, principally the stomach, for the problems of removal are essentially the same as those for other intra-abdominal neoplasms. The nerve sheath tumors of the mediastinum and thoracic cage necessitate a detailed and rather specialized technic which is beyond the scope of the present communication, but valuable contributions have been made to this field, particularly by Harrington¹⁰ and Heuer.¹¹ In the following discussion* some of the more commonly employed procedures are described first, leaving until later other considerations such as selection of operation and postoperative care.

Preoperative Considerations.—The anesthetic employed need give little concern, for a wide variety can be chosen from if there are no complicating factors. Ether, avertin-ether, or nitrous oxide-oxygen-ether all serve admirably. Spinal anesthesia is preferable for operations upon the legs. One should not attempt, however, to remove one of these neoplasms under local conduction anesthesia, for injection of novocain directly into a large nerve trunk is too apt to produce injury and subsequent neuritis.

The armamentarium need include but few special instruments. A blunt end nerve hook will be found desirable in handling small trunks. Delicate smooth and mouse tooth forceps are essential. Silver clips may be found useful for controlling bleeding vessels on the surface of or in the substance of a nerve. Fine silk is far superior to catgut if repair or end-to-end suture of a nerve trunk is to be done. Black silk of size 1 is suitable, but if this is not available, No. 4 (A silk) can be split into its three separate strands

* Three of the cases cited here for illustrative purposes were operated upon by Dr. Harvey Cushing, Dr. David Cheever and Dr. John Homans to whom we make grateful acknowledgment.

and one of these will be of correct diameter and strength. Commercially prepared blood vessel suture silk is excellent. The needles should be small, curved, semi-curved and straight, with closed eyes. These can be threaded beforehand and if sterilized in oil or waxed they will be found to slip more easily through nerve tissues if repair is performed.

OPERATIVE PROCEDURES.—*Excision of Tumor from Within Trunk Without Division of Functionally Active Fibers.*—If the tumor is a benign neurofibroma or neurilemmoma, it is permissible to shell it away from the nerve trunk. It is of prime importance to recall that the benign nerve sheath tumor (unassociated with von Recklinghausen's disease) grows in such a way as

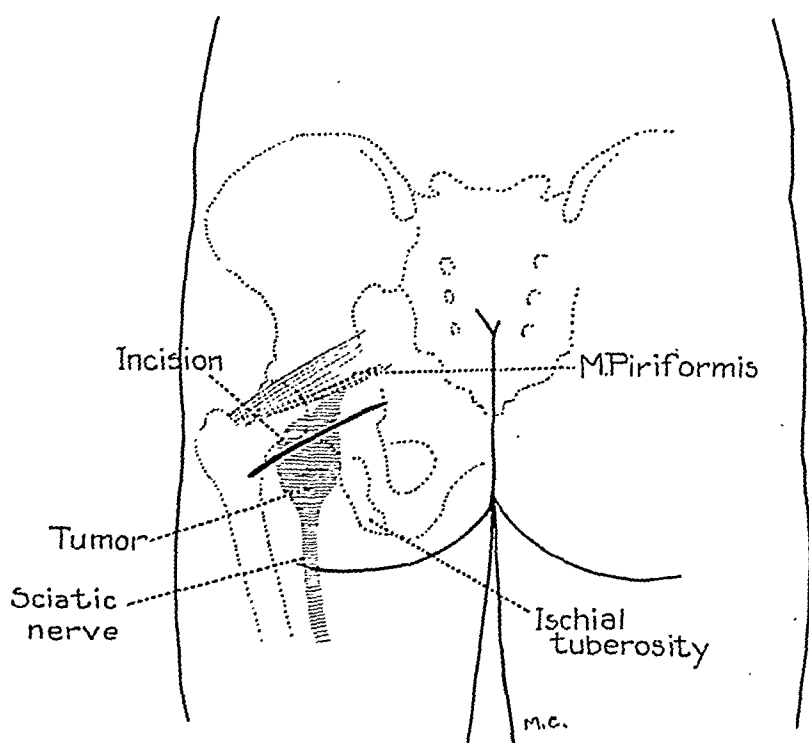


FIG. 1.—Schematic drawing to show position of a benign perineurial fibroblastoma of the left sciatic nerve from a case treated as indicated in Figs. 2, 3 and 4.

to push the nerve trunk to one side or to expand it. The nerve proper does not, therefore, directly enter the mass but is displaced laterally or is pushed out so as to completely surround the neoplasm. Thus one always finds a good line of cleavage which permits dissection of the tumor away from the nerve without severing its fibers or disturbing their functional integrity. When the nerve lies toward one side, it can, of course, be dissected off with ease. If, however, the nerve completely surrounds the mass, the covering fibers must be incised longitudinally to permit withdrawal of the central growth. Figs. 1 to 4 illustrate such a treatment in removal of a lemon-sized perineurial fibroblastoma of the sciatic nerve in one of our cases. After this dissection the nerve may be frayed out or indeed may consist of little more than a flabby, collapsed shell, but it can be dropped back into the wound and there may be little or no sensory or motor disturbance in the area which it supplies. If longitudinal incision has been made in the nerve trunk to permit

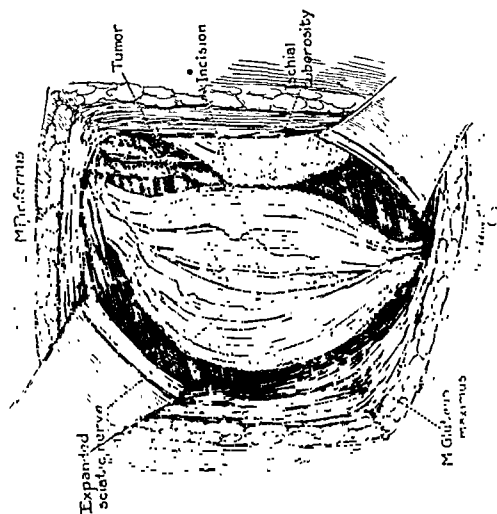


FIG. 2.—Operative exposure of a perineurial fibrosarcoma of the sciatic nerve in the buttock (compare with Fig. 1). The gluteus maximus muscle has been split and the edges retracted. Fibers of the sciatic nerve are expanded around the neoplasm. Incision is made parallel to the nerve fibers in order to reach the central mass.

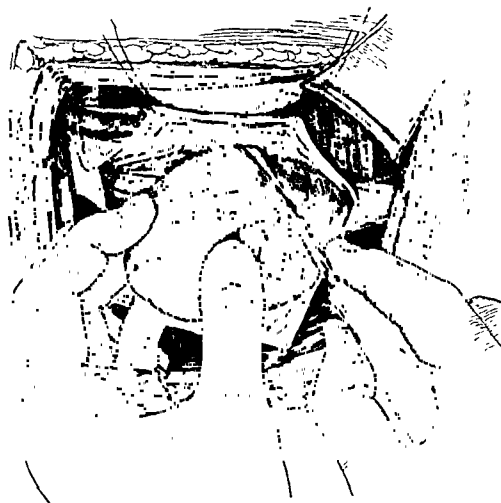


FIG. 3.—Removal of a benign nerve tumor from the sciatic nerve (see Figs. 1 and 2). The sciatic nerve is split open and its edges gently retracted with silk stitches. The neoplasm is shelled out from its bed by blunt dissection.

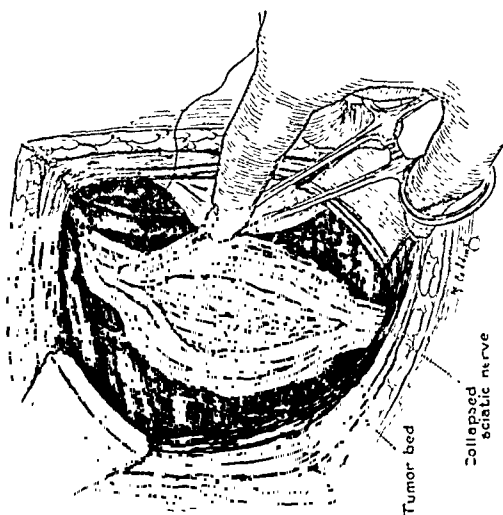


FIG. 4.—Repair of nerve trunk following extirpation of a neurofibroma (see Figs. 1 to 3). The separated edges of the nerve are lightly approximated by a few silk stitches. The nerve, though stretched and flabby, remains functional.

TUMORS OF THE PERIPHERAL NERVES

enucleation of a tumor, the edges of this defect can now be brought together with a few interrupted silk sutures (Fig. 4). Such approximating sutures should be of the finest silk and loosely tied so as not to injure apparently healthy nerve fibers.

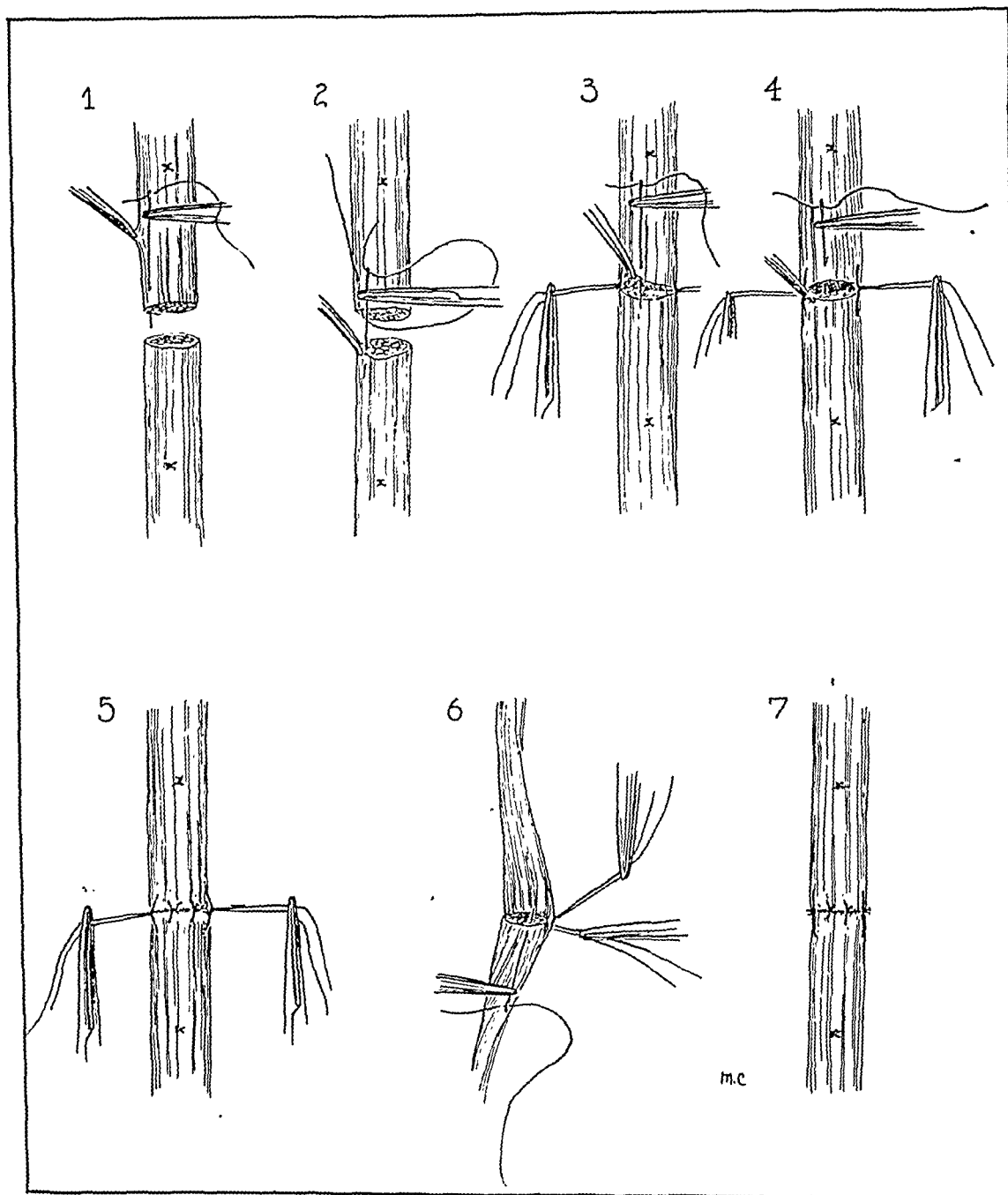


FIG. 5.—Method of end-to-end nerve suture. Note in all of the sketches the small identification knots (placed before the nerve was divided) which serve to prevent rotation of the proximal or distal segments. (1) Fine straight needle passed through epineurium. (2) Stitch carried through covering of opposing nerve end. (3 and 4) First two (diametrically opposite) stitches left long and snapped for purposes of handling the nerve. Intermediate sutures being placed. (5) Sutures completed on front of nerve. (6) Nerve rotated for placing of posterior sutures. (7) Repair completed.

Excision of Tumor with Division of Nerve.—The second and less commonly employed method of nerve tumor excision is to make a clean and complete resection of the mass so as to include a portion of nerve proper. If the nerve which is thus surgically severed is a small subcutaneous one or is

an unimportant branch, no attempt at repair is necessary. If, however, the trunk is large, it is definitely the duty of the surgeon to attempt an immediate restoration by end-to-end sutures. Such a reconstruction is relatively easy to perform, but care and delicacy must be exercised to establish a nice approximation of the divided nerve ends in order to reduce the possibility of subsequent neuroma formation and to give the best possible chance for reestablishment of nerve function.

A number of methods have been described for end-to-end nerve suture and the steps indicated in Fig. 5 represent an acceptable operation. The ends of the nerve must be cut cleanly at right angles to the long axis of the trunk. Two guy sutures are then placed (Fig. 5). These sutures include 2 or 3 Mm. of the nerve end and pass through the ensheathing epineurial coat only, for this is the strongest portion of the nerve and must be employed to give

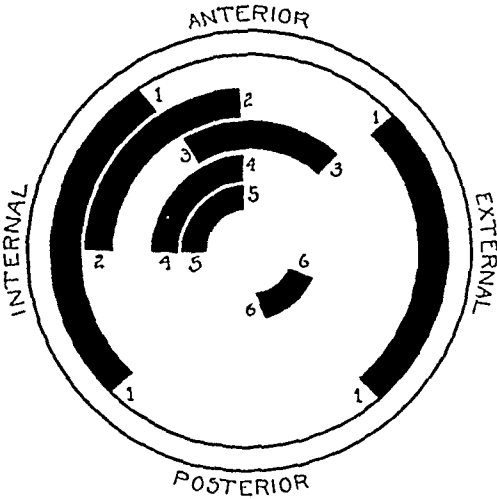


FIG. 6.—Schematic cross-section of median nerve at the midarm level (from Kraus and Ingham) showing position of bundles as determined by electrical stimulation of this level. (1) Pronator radii teres; (2) flexor carpi radialis; (3) palmaris longus; (4) flexores digitorum; (5) flexor pollicis; (6) pronator quadratus.

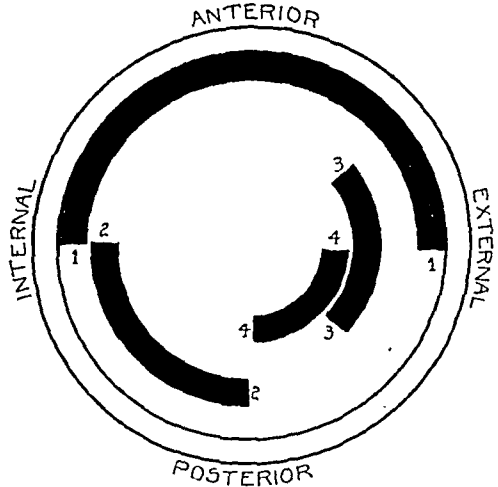


FIG. 7.—Schematic representation of funicular topography of median nerve at midforearm level (from Kraus and Ingham). (1) Sensory; (2) opponens pollicis; (3) abductor pollicis; (4) lumbricales.

strength to the suture line. Under no circumstances should these sutures pass diametrically through the nerve, for in such a location they tend to buckle the nerve union and to impede the progress of regenerating axis cylinders. These first two stitches are left long and are used for traction in order that the nerve may be held and rotated during placement of the remaining sutures (steps 5 and 6, Fig. 5). Babcock¹ has devised a clamp by means of which the two ends of the nerve may be held by small piercing wires and thus be brought together and handled during the steps of suturing. With the ends of the nerve drawn together, additional interrupted sutures may now be placed around the entire periphery of the nerve, the total number varying from four or five in a small trunk to as many as 12 or 15 in a large nerve such as the sciatic. The nerve should be picked up with the finest of forceps, and only the outer covering need be grasped during the manipulations. The

nerve tissue tends to dry quickly and hence should be kept moist with saline while it is exposed.

When any nerve is divided and repaired by end-to-end suture, great care must be taken to prevent rotation of the two cut ends when they are sutured. It has been shown that fibers coursing to muscle groups are isolated into more or less segregated portions of a nerve trunk (Figs. 6 and 7), and hence

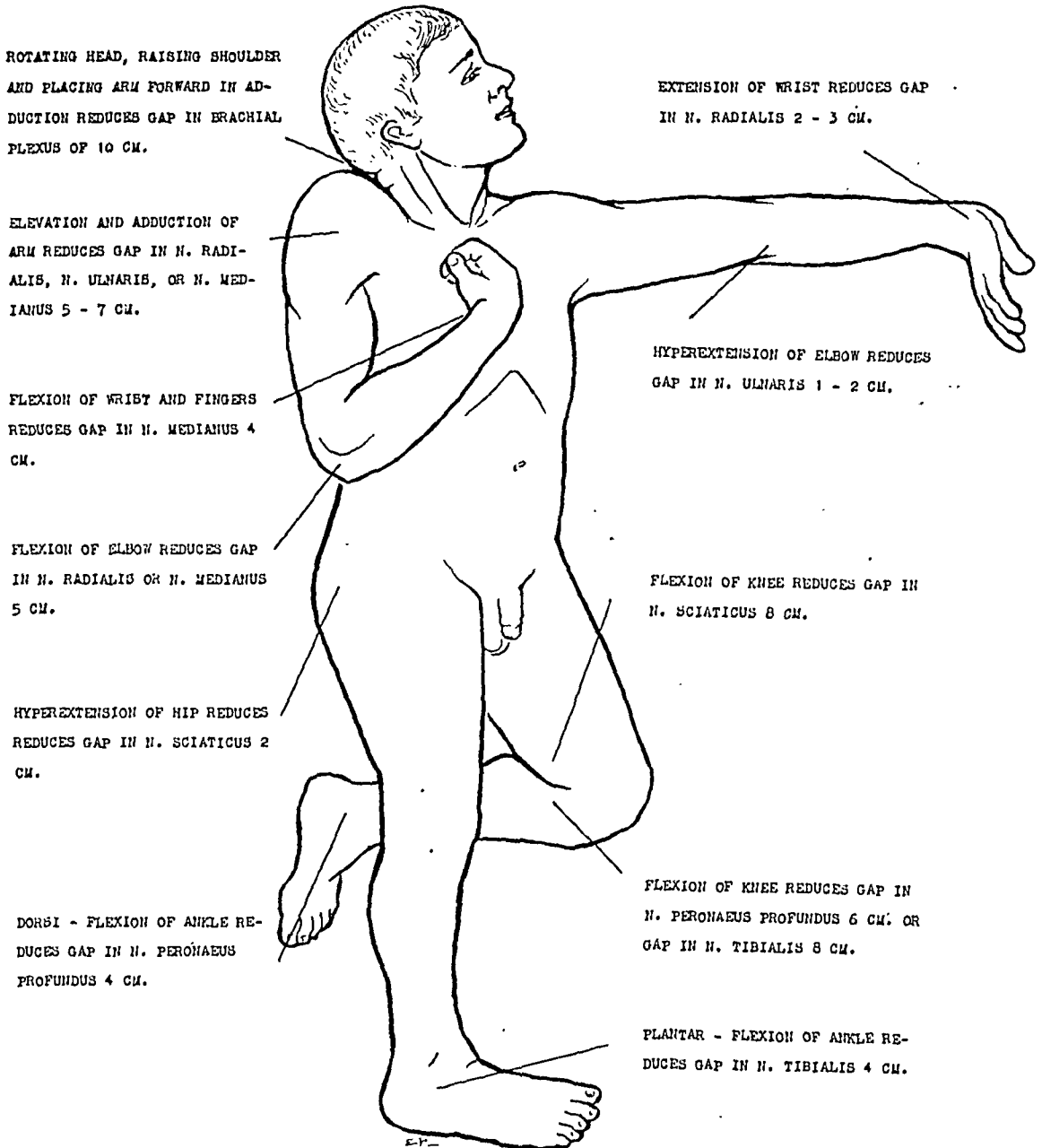


FIG. 8.—Diagrammatic representation of the amount of nerve defect which may be overcome by movement of joints as indicated (after Babcock).

an attempt must be made to join the two ends so that the bundles of the proximal portion will lie in apposition to the corresponding funiculi of the distal end. This will insure the best possible chance for the regenerating axones to grow out into their proper peripheral distribution. A good way to guard against rotation of the two ends is to place two small silk ties on

one surface of the nerve before excision of the tumor. These knots then serve as identification sutures during the various stages of end-to-end suture (Fig. 5).

The great size attained by many of the peripheral nerve tumors may appear to militate against excision of the nerve trunk for fear of not being able to subsequently bring the divided ends together. The general rule may be stated, however, that one never encounters a nerve tumor so large that removal of the involved nerve trunk prohibits bringing together of the divided nerve ends. The only exceptions to this are provided by neoplasms of the thorax and, rarely, by some of those arising in the neck. In the arms and legs, however, it is remarkable what lengths of nerve gaps may be closed by employing one or several of the following important procedures:

(1) The normal elasticity of the nerve allows it to be stretched for lengths varying from 1 to 2 cm., depending upon the nerve under consideration. This small but important degree of slack may be utilized without placing undue tension on the suture line.

(2) The proper position of a limb adds a considerable additional available length which may be employed in reducing a nerve gap. Babcock² has had a most extensive experience with peripheral nerve injuries and has employed this method with unusual success, reducing the nerve gaps in various nerves by the maximum amounts indicated in Figure 8.

(3) Additional lengths may be obtained in a nerve trunk by rerouting. Not all nerves lend themselves to this procedure, but a familiarity with the technic will occasionally permit a reduction of a nerve gap not obtainable by any other operation alone. The ulnar, median, radial and tibial nerves offer the best branches for this procedure. The ulnar nerve may be loosened from its bed at the elbow and by changing its position so as to make it lie in front of the internal epicondyle of the humerus, an additional 2 cm. may be gained. The radial nerve may be unwrapped from the humerus and upper arm muscles, and by displacing it to lie on the anteromedial aspect of the upper arm an additional 3 to 4 cm. may be added to its length. The median nerve can be displaced from its deep bed and by raising it to a position superficial to the forearm muscles a length of 2 cm. can be gained. In performing these procedures great attention must be paid to the twigs supplying surrounding muscles and these individual fibers may be stripped back along the nerve so that they take origin higher up than they did formerly. By this procedure these muscle branches are damaged only a negligible amount. The tibial nerve can be displaced to a position in front of the internal malleolus, an additional 2 to 3 cm. being gained thereby. Rerouting of a nerve necessitates very liberal exposure and unless one is prepared to make an unusually long incision, the operation is doomed to failure.

Table I indicates the maximum amount of gap which may be reduced in various nerves (Babcock) by taking advantage of the normal nerve elasticity by proper position of the neighboring joints, and by rerouting.

TUMORS OF THE PERIPHERAL NERVES

TABLE I

MAXIMUM GAPS IN PERIPHERAL NERVES IN WHICH END-TO-END SUTURE
IS POSSIBLE (AFTER BABCOCK)

	By Slack and Elasticity cm.	By Joint Position cm.	By Rerouting cm.	Totals cm.
Brachial plexus.....	1.5	3-7	....	11.5
Radial in arm.....	3.0	5-7	....	15.0
Radial in forearm.....	1.5	4-5	....	10.5
Ulnar in arm.....	3.0	7	6	16.0
Ulnar in forearm.....	1.5	5	6	12.5
Median in arm.....	3.0	5-7	....	15.0
Median in forearm.....	1.5	3-4	14.5	23.0
Sciatic.....	3.0	3-8	....	14.0

The plexiform neuromata of von Recklinghausen's disease are so variable as to make it impossible to standardize the different therapeutic procedures. Occasionally, however, one is fortunate enough to encounter a localized form of the disturbance and the irregular, nodular enlargements of the superficial or subcutaneous nerves can be easily dissected out. As the twigs involved are often small or sensory ones, no nerve repair is usually required. If the overlying skin is pigmented or pedunculated, portions of it may be excised to gain a good cosmetic result, the cutaneous defect being closed by plastic procedures as the circumstances demand.

The neck is one of the most common sites for the nerve sheath tumors, particularly the benign perineurial fibroblastoma, which may arise from any one of the numerous sympathetic, cranial or somatic nerves which richly traverse this region (Figs. 9 and 10). One must be prepared to dissect deeply for these neoplasms which may be attached to the roots of the cervical plexus or extend to the very base of the skull if they arise from the vagus. When they originate from the cervical roots (most commonly the dorsal) dumb-bell shaped or hour-glass tumors¹¹ may lie partly in the spinal canal and also out in the soft tissues of the neck, hence the unwary operator may be led into a more extensive undertaking than had been anticipated. If the nerve trunk is divided in removing one of these cervical neoplasms, every effort should be made to resuture the cut ends, this consideration being most important in division of the hypoglossal nerve in order to prevent extensive atrophy of the tongue muscles.⁷ On two occasions we have purposely divided the left vagus nerve without being able to repair it, and in neither case could we detect any disturbance in the cardiac or intestinal mechanisms post-operatively. In one of these cases a permanent hoarseness followed operation. On the whole, however, one commonly finds that it is possible to peel these cervical tumors away from the nerves which give rise to them and it is rarely necessary to completely divide one of these important trunks.

The thorax, while presenting relatively few of the nerve sheath tumors,

contributes an especially interesting chapter for the benignity of these neoplasms in the mediastinum or chest wall and makes their removal a most satisfactory undertaking. One of these cases in our series had a hen's egg size perineurial fibroblastoma of the superior mediastinum which was successfully removed by opening into the mediastinum through the sternum. The upper portion of the sternum was transected between the first and sec-

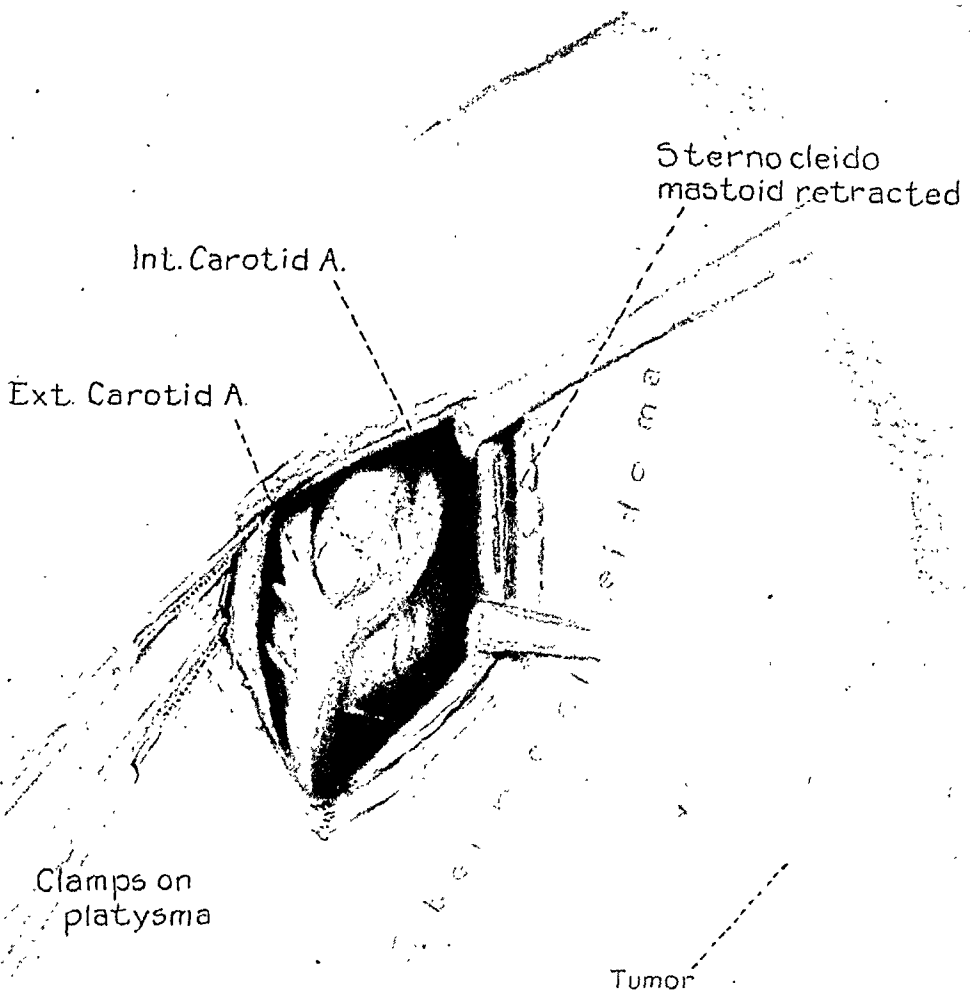


FIG. 9.—Operative exposure of a deeply attached cystic neurofibroma of the neck. A segment of the internal jugular vein has been resected to gain access to the neoplasm. The external carotid artery is compressed anteriorly and the internal carotid artery is pushed laterally. The mass was cleanly excised. Insert shows position of the tumor.

ond ribs and between the third and fourth ribs by the use of a Gigli saw. Cutting through the second and third costochondral junctions on either side then permitted the turning to the right of a skin, muscle, and bone flap, leading into the mediastinum as through a trap door (Fig. 11). Keller and Callender¹⁴ removed a neurofibroma at the lower end of the left phrenic nerve, approaching it by an incision through the left fifth interspace, dividing and spreading the fifth and sixth ribs upward and downward respectively.

TUMORS OF THE PERIPHERAL NERVES



FIG. 10.—Photograph of neurofibroma of the neck showing extensive cystic degeneration. (From same patient as Fig. 9.)

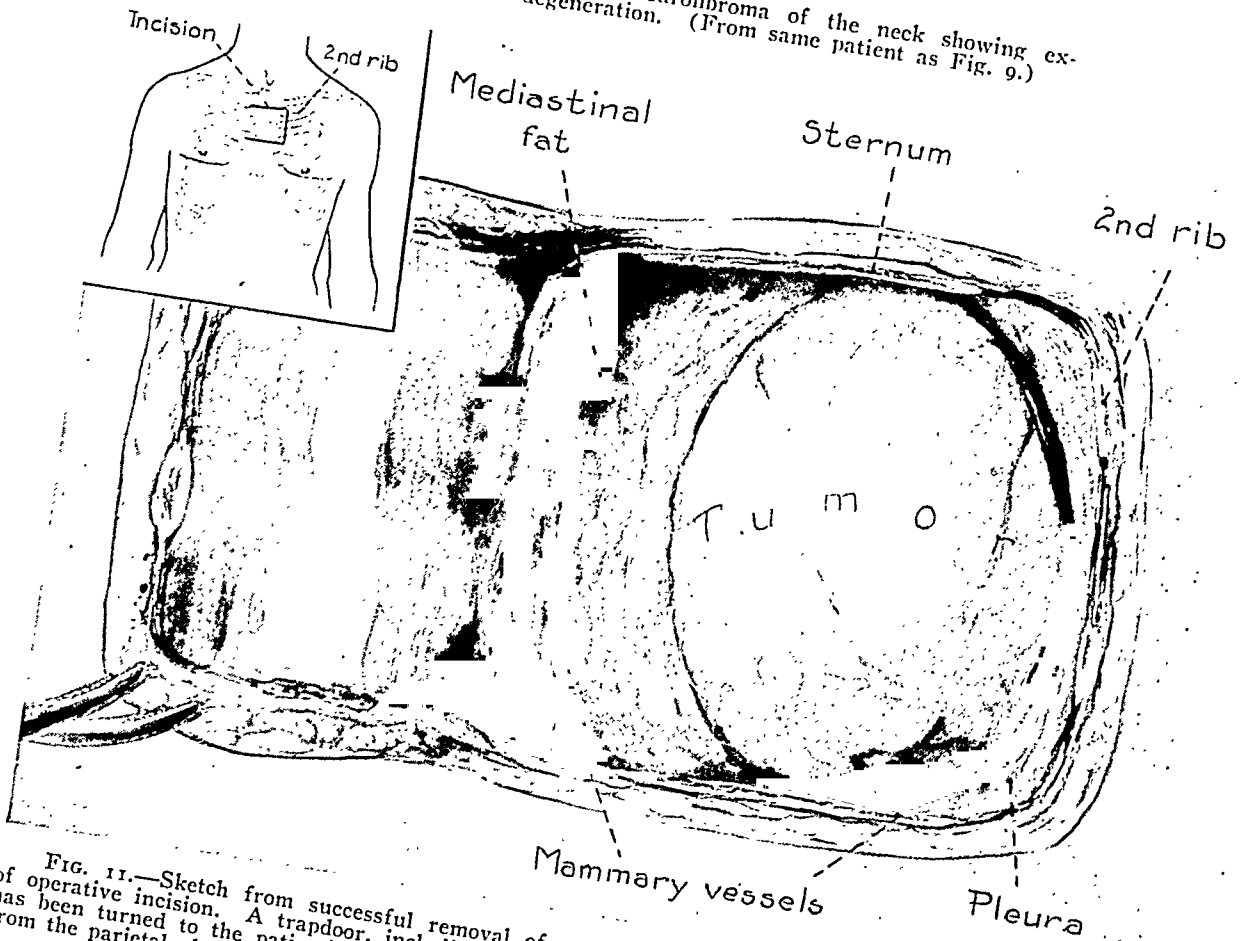


FIG. 11.—Sketch from successful removal of a mediastinal neurofibroma. Insert shows position of operative incision. A trapdoor, including skin, subcutaneous tissues and upper portion of sternum has been turned to the patient's right. The tumor was shelled out from its bed and dissected away from the parietal pleura on its left and the great vessels which lay deeply toward its right.

This gave good access to the region between the pericardium and the left parietal pleura.

In one of our patients with a large orange size perineurial fibroblastoma of the posterior portion of the right eighth intercostal nerve a successful and easy extirpation was completed by removing the posterior one-half of the ninth rib subperiosteally and then cutting across the eighth and tenth ribs posteriorly so that these latter could be spread apart. The pleural cavity was then entered by an incision through the bed of the ninth rib and the tumor, which projected into the thoracic cage, was easily excised from its attachments to the eighth intercostal nerve.

The posterior mediastinum is by far the best known site for the nerve tumors of the thorax. Since the spinal cord roots as well as the sympathetic nerves account for these posterior tumors, one finds that they lie close to the spinal column and extrapleurally. Thus they can usually be removed without entering the pleural cavity if a careful dissection is made. The operative approach then is usually by way of a paravertebral incision, cutting through the necks of two or more ribs to permit their separation. Again, one must be prepared to deal with an hour-glass tumor, opening the spinal canal at the same or subsequent sitting as the findings demand.

Postoperative Care.—Other than the usual care of the wound, little need be said concerning postoperative treatment excepting in those occasional cases in which a nerve trunk has been divided and resutured. When this latter has been done, the postoperative treatment should include an immobilization of the extremity, a graded return of motion of the part, and physiotherapy to those regions which are temporarily deprived of their nerve supply.

Immobilization is required to permit proper healing of the suture line and to give the best possible chance for the regenerating axis cylinders to grow down the distal part of the nerve trunk. It is especially necessary when a nerve gap has been overcome by flexing (or otherwise adjusting) the contiguous joints, because movement of these joints may tear apart the nerve repair. The duration of such immobilization must, of course, be decided for the individual case, but certainly it should never be less than three or four weeks and should better be maintained until there is evidence of return of nerve function. It is safer to err on the side of immobilizing too long rather than too short a period.

A graded return of motion should be ordered for the immobilized extremity. If a joint has been fixed in a given position to permit obliteration of a nerve gap, it is best to adopt some set schedule for reestablishment of the normal range of motion of this joint. Thus, if the elbow has been flexed at a 90° angle to permit suture of the median nerve in the antecubital fossa, it is best to maintain this right angle for a period of about one month and then to increase the extension at the elbow by two degrees daily, thereby passing a total of two and one-half months before getting the forearm straightened out to 180° .

Physiotherapy has a definite place in the postoperative regimen, for by

its judicious use the distal musculature and soft parts can be maintained in the best possible condition, and atrophy partially prevented while waiting for regeneration of the nerve. Baking and massage given daily or three times a week as the economic conditions warrant should be continued until restoration of active motion in all the paralyzed muscles heralds the return of nerve function. Physiotherapy can be administered while the limb is partially loosened but not removed from such immobilization apparatus as might be employed. Former teachings advocated the use of electrical stimulation of paralyzed muscles but experience has shown that this has little additional advantage and hence can be omitted with impunity.

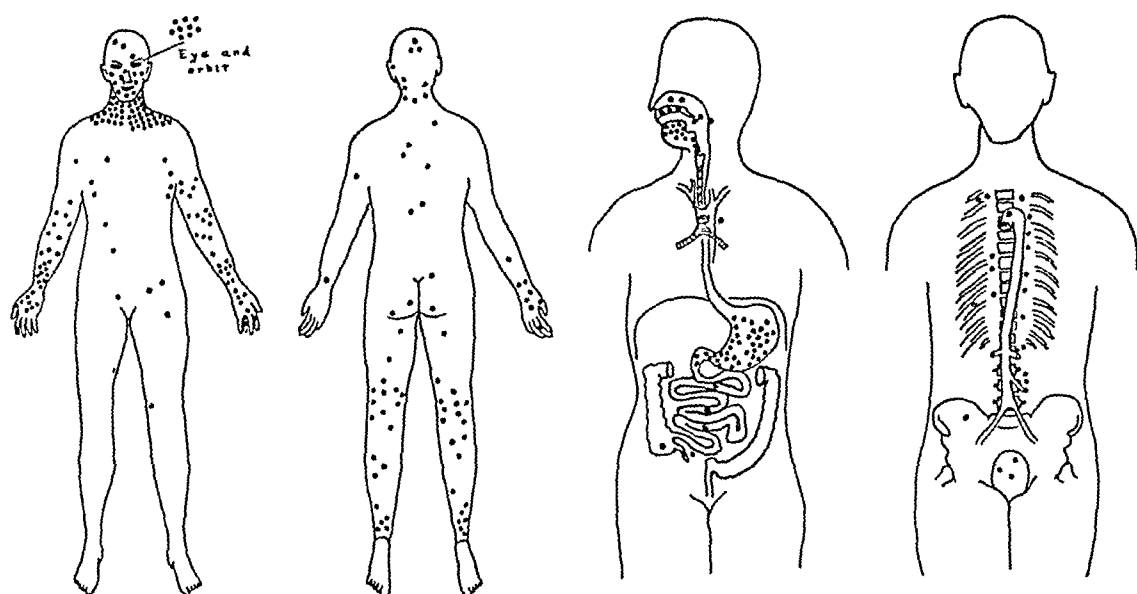


FIG. 12.—Distribution of benign perineurial fibroblastoma (from Stout, to which are added 17 cases of Mayo and Barber and 20 personally observed cases).

The length of time necessary for reestablishment of muscular and sensory function, naturally, depends on the length of the nerve trunk distal to the point of its severance and end-to-end suture. In general, under optimum conditions, the axis cylinders will regenerate at the rate of about 1 Mm. per day or roughly one inch per month. If there is no evidence of returning nerve function in twice the time calculated and allotted for its reestablishment, it is likely that the nerve suture has broken down and the ends separated or else a neuroma has formed at the site of operation and secondary suture in all probability will be required.

Choice of Treatment in Various Types of Peripheral Nerve Tumors.—The important tumors of the peripheral and sympathetic nervous systems may be classified as follows:

- (1) von Recklinghausen's disease (neurofibroma).
 - (2) Perineurial fibroblastoma (neurilemmoma, schwammoma).
 - (3) Malignant perineurial fibroblastoma (malignant neurofibroma).
 - (4) Neurofibrosarcoma (neurogenic sarcoma).
- Arising in von Recklinghausen's disease.
- Arising in perineurial fibroblastoma.

- (5) Cyst (?degenerated perineurial fibroblastoma).
- (6) Neuro-epithelioma.
- (7) Ganglioneuroma.

von Recklinghausen's disease in its generalized form usually does not call for operative treatment, but when it occurs as an isolated lesion or in the "forme frustes" the possibility of complete eradication makes surgical intervention advisable. Such plexiform neuromata can be dissected out with more or less ease, depending upon the extent and depth of the pathologic process. The generalized types of the disease may require surgery when large pedunculated masses cause discomfort and when undue rapidity of

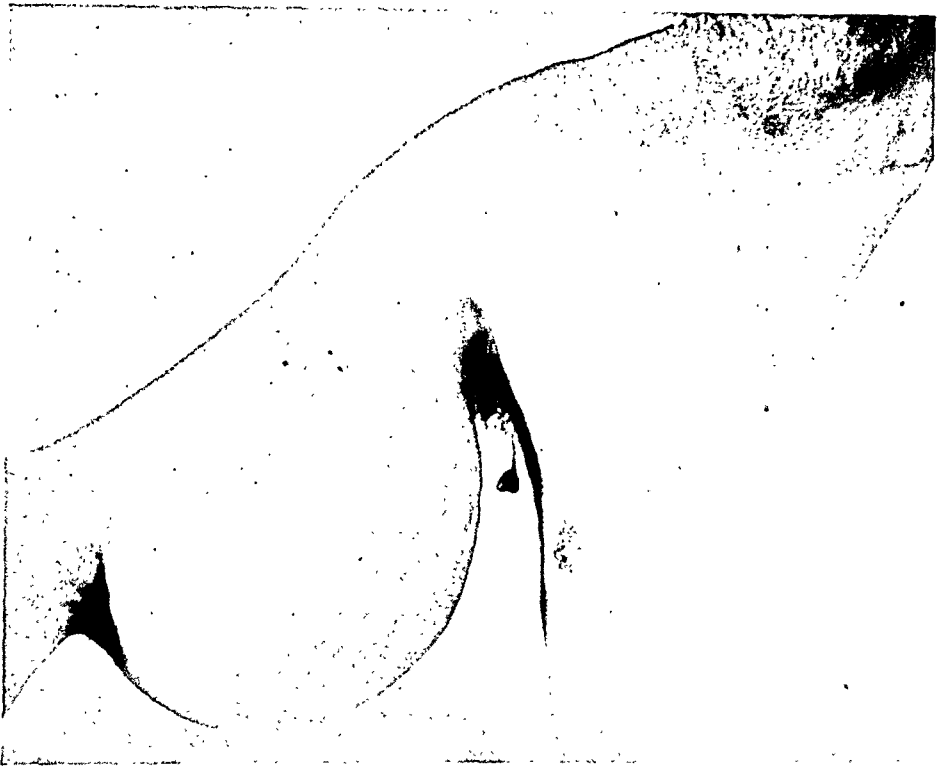


FIG. 13.—Neurofibrosarcoma of the median nerve in a 56 year old man. Small mass had been present for 20 years—followed by recent rapid growth and doubling of size in four months. Apparently malignant change in a previously existing neurofibroma. (No stigmata of von Recklinghausen's disease.)

growth suggests the possibility of malignant degeneration—a transformation which occurs in about 15 per cent of cases of von Recklinghausen's disease.

The perineurial fibroblastoma can practically always be treated by conservative surgery, for these lesions are slowly growing and if cleanly removed they rarely recur. When attached to small subcutaneous nerves, removal of a bit of the nerve causes little disability, but if the mass arises from a large nerve, it should be peeled away so as to leave the trunk intact. Figure 12 indicates the common positions of these growths, and as is seen, the most frequently involved sites are the neck, the front of the arms, and the backs of the legs.

The term malignant neurofibroma has been adopted by us to designate

several specimens which have shown a marked tendency to local recurrence and regional extensions. These uncommon growths do not exhibit a high degree of malignancy and do not metastasize by way of blood stream or lymphatics. They do, however, produce important local and regional invasions. While some authors have classified these neoplasms as slowly growing neurofibrosarcomata, we have preferred to employ a different term in speaking of them in order to point out their activity, which lies halfway between the neurofibroma or perineurial fibroblastoma on the one hand and the neurogenic sarcoma on the other. Their surgical treatment calls for a local but radical resection, and under no circumstances should attempts be made to separate them from the nerve trunk for this will almost certainly lead to recurrence and will doom to disaster a condition which previously had been

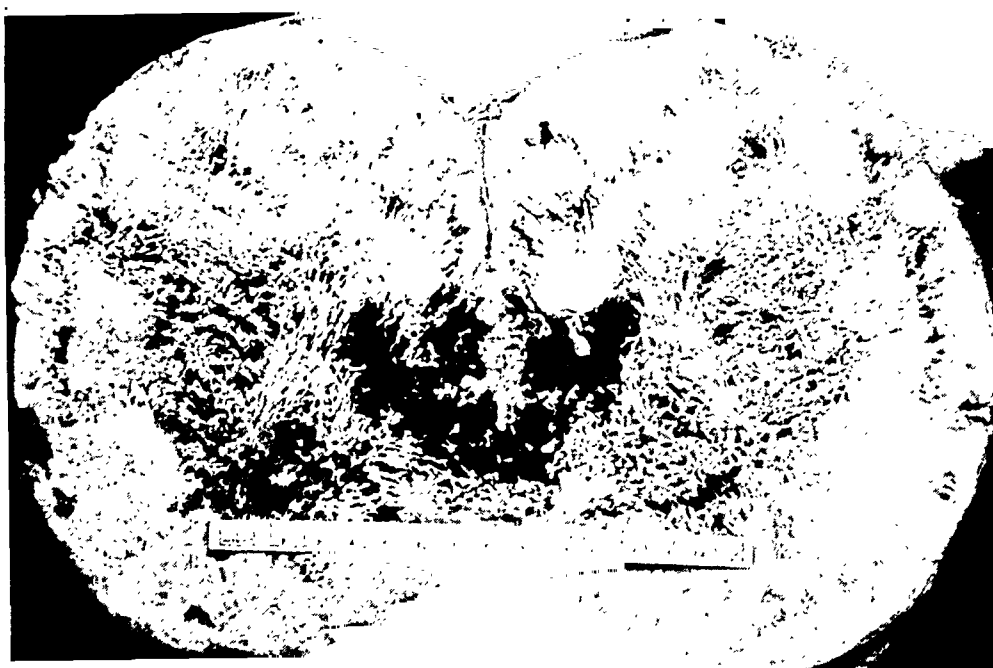


FIG. 14.—Rapidly growing neurofibrosarcoma of the median nerve. Specimen from case illustrated by Fig. 13.

curable. The excision, therefore, should always include a portion of the nerve trunk, which can be repaired at the same sitting by an end-to-end suture. We have justified this procedure in our own experience by removing such a neoplasm with a segment of the posterior cord of the brachial plexus. In spite of the postoperative total paralysis of radial and axillary nerves, the muscular and sensory functions of these nerves were completely restored in the arm within two years and there has been no evidence of recurrence of the neoplasm.

The neurofibrosarcomata, in the absence of demonstrable metastases, should be attacked radically from the outset. No form of local removal should be considered adequate if the growth appears on a limb, for early amputation may be a life-saving procedure. If pathologic examination of a specimen shows a sarcomatous growth in what was preoperatively thought to

be a benign lesion, amputation can be performed secondarily with some hope of cure. It must be noted, however, that one's suspicions concerning malignancy should be aroused before operation for there is almost invariably a history of rapid growth in a period of a few months or else there has been a sudden increase in size in a previously existing long standing benign tumor. If, therefore, a recent rapid growth has been noted, preparations should be made for competent pathologic examination at the time of operation, so that amputation can be done immediately if necessary. It is almost safe to say, however, that if there has been a recent marked increase in the size of the mass and if at operation there is no hemorrhage or cystic degeneration to account for this, the tumor may be considered almost certainly a malignant one. Figs. 13 and 14 are from a case of neurofibrosarcoma of the median nerve in a man 56 years of age. Fig. 15 shows the distribution of 137 malignant, nerve sheath tumors as compiled by Stout.

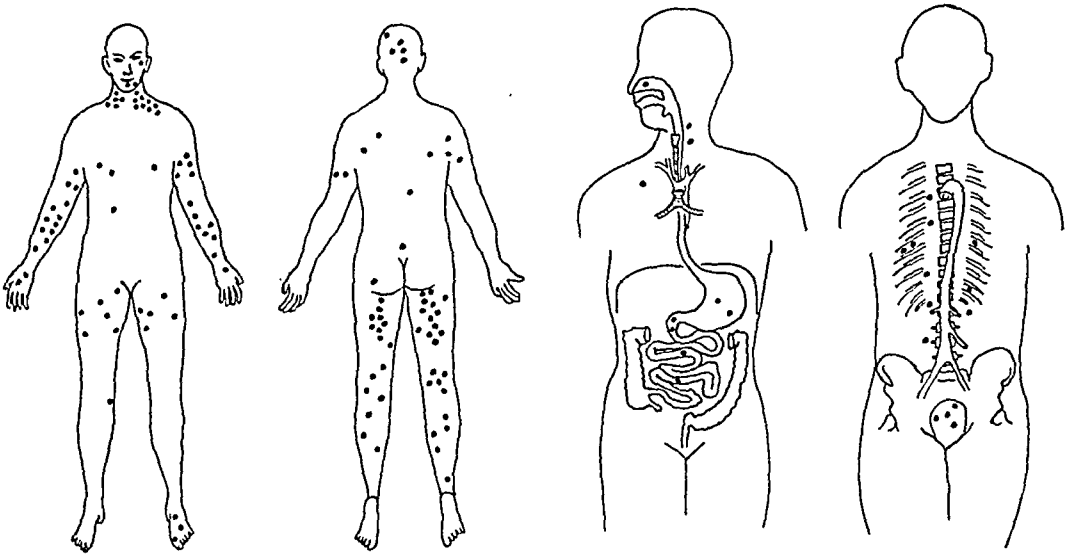


FIG. 15.—Distribution of 137 malignant nerve sheath tumors, occurring in 100 patients with von Recklinghausen's disease and in 29 patients without such stigmata (from Stout).

Cysts of the nerve trunk occur with rarity and their origin is not clearly understood. Since it is well known, however, that marked cystic degeneration often takes place in a perineurial fibroblastoma, it is only reasonable to believe that these nerve cysts, filled with watery or gelatinous fluid, take their origin from a previously existing nerve sheath tumor. The treatment, therefore, should be conservative, and consists of a simple dissection of the thin-walled sac away from the adjacent or surrounding nerve with as little interruption of the nerve fibers as is possible. The nerve can be split longitudinally so as to expose the cyst which lies within its substance, and by this technic the functional integrity of the nerve is not impaired.

Treatment of nerve cysts raises another possibility, namely, aspiration of the cyst or aspiration combined with injection of sclerosing fluids. Such therapy need only be rarely employed, but on one occasion we found it useful in treating a cystic, malignant neurofibroma of the face. In this patient a

large external mass in the region of the left zygomatic bone, extended internally to displace and involve the left side of the soft palate. Complete surgical removal was obviously impossible because of the anatomic location and only enough tissue for biopsy purposes was removed. Aspiration of the cyst, however, afforded considerable relief to the patient and the injection of fixative agents theoretically killed off a narrow rim of tumor remaining around the cyst wall.

The neuro-epitheliomata are lesions of an extraordinary high degree of malignancy and the same may be said regarding their treatment as was noted regarding the neurofibrosarcomata.

The ganglioneuromata are tumors of not too common occurrence, but their relative benignity and the fact that more than one-third of them are seen in childhood makes surgical removal a satisfactory and worthwhile procedure. McFarland and Sappington¹⁹ collected 143 examples of this tumor from the literature. Among these cases the three most commonly involved sites were: retroperitoneal, 26; cervical, 17; thorax and mediastinum, 11. These neoplasms are well encapsulated, usually quite slowly growing and can be removed by local excision with a considerable degree of success and freedom from recurrence.

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BENIGN METASTASIZING HEMANGIOMA

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A SMALL group of hemangiomata is characterized by extensive metastases, in spite of the seemingly benign histologic structure of both the primary and secondary tumors. Only four apparently authentic cases of this condition have been reported: Borrmann,¹ 1906; Shennan,² 1914; Ewing,³ 1919; Geschickter and Keasbey,⁴ 1935. They have given rise to considerable discussion because the existence of such a group has an intimate bearing on the question of the essential similarity of benign and malignant processes and because they are difficult to classify. Some authors (Jaffe,⁵ Wollstein,⁶ Taylor and Moore,⁷ and others) have even attempted to discredit altogether the criteria on the basis of which these tumors have been grouped together.

We have recently had the opportunity to study a case which helps to clarify the paradox of a metastasizing benign tumor.

CASE REPORT

An 18 year old American girl entered the Tumor Clinic of the Massachusetts General Hospital complaining of a painless enlargement of the right breast of six months' duration. Three months after the lesion was first noted the breast became discolored and shortly afterward painful. Examination on admission showed that the right breast was about twice its normal size, forming a firm elastic mass with a purplish discoloration surrounding the nipple for about 8 cm. (Fig. 1). There was no increase in local temperature, no pulsation in the mass, and no discharge from the nipple. A small pigmented nevus was present on the opposite breast, but no other skin tumors were seen.

A preoperative diagnosis of hemangioma was made and a simple mastectomy performed.

Gross examination showed a right breast measuring 14.5 x 11.5 x 8.5 cm. covered by an elliptical piece of skin 14.5 x 8.5 cm. The nipple was negative. Just to one side of the nipple there was a mottled purplish discoloration of the skin over an area 5 x 3 cm. in size. Nearly all the breast tissue was replaced by a large, fairly well encapsulated, rather soft, mottled, purplish-gray tumor 10.5 cm. in diameter and 3 cm. in thickness. The capsule was quite adherent around the periphery and in places could not definitely be made out. The cut surface was edematous, light gray in color, and honey-combed with small cystic spaces filled with blood.

Microscopic examination showed a lesion consisting of small and large cystic spaces filled with blood and lined by small, uniform, apparently quite well differentiated endothelial cells. No mitotic figures were seen (Fig. 2). The lesion extended widely throughout the breast tissue, showed slight invasive properties, but no histologic evidence of rapid growth. Because of this tendency to infiltrate the breast tissue and in spite of the fact that its structure was that of simple angioma, the tumor was not considered entirely benign.

Eight months after the mastectomy the patient returned to the hospital. A keloid had developed in the scar and two small hemangiomata had now appeared, one over the right lower ribs posteriorly and the other in the right supraclavicular region. During

the following month two more lesions appeared, one on the chest, 1.5 x 1.3 cm. in extent, and the other on the scalp, 5 x 3 cm.

At this time roentgen therapy was started. During the next four months all the lesions except that in the scalp received three to four doses of .8 skin units* superficial therapy at monthly intervals. At the end of this period the treated lesions showed considerable flattening without, however, any definite decrease in width. The scalp lesion was then treated with monthly doses of .8 skin units for three months. Two new lesions appeared on the abdomen, followed rapidly by numerous others over the abdomen and back. An attempt to treat all of these was quite impractical. The scalp tumor began to grow rather rapidly, reaching three times its original size. It was then excised—one year after it was first noted, 20 months after the original mastectomy.

The pathologic diagnosis was hemangiosarcoma. This metastasis was quite different from the original tumor. The cystic angiomatous spaces had disappeared. The cells were quite spindle shaped, small, contained hyperchromatic nuclei, and were definitely



FIG. 1.—Showing the enlargement of the right breast, when first examined.

angioblastic. Mitotic figures were present and there was definite evidence of infiltration (Fig. 3).

Since there did not appear to be any involvement of the internal organs, an attempt was made to determine the radiosensitivity of some of the individual skin lesions. Two groups were selected: (1) the older lesions previously treated with superficial roentgen ray and (2) a few of the recent untreated masses. Each lesion received during a two week period 1,600 r (two erythema doses) of medium wave roentgen ray in one dose. A few received 3,200 r in two doses. Two months later the skin over the treated areas was flat and scaly; no masses could be felt. The untreated lesions, however, had grown slowly although no new tumors appeared. An hemangioma in the left breast

* A skin unit refers to a threshold erythema dose (350 r) of superficial or long wave roentgen ray delivered at 100 kilovolts, 5 milliamperes, 8 inch distance, .5 aluminum filter. "Medium wave therapy" refers to roentgen rays delivered at 140 kilovolts, 5 milliamperes, 4 Mm. aluminum filter, 50 inches. "Deep therapy" refers to short wave roentgen rays delivered at 200 kilovolts, 50 cm., 5 milliamperes, .5 Mm. copper filter. In the case of medium and deep roentgen ray therapy, 800 r measured in air is considered the equivalent of an erythema dose.

BENIGN METASTASIZING HEMANGIOMA

which was treated with 900 r right side and 900 r left side deep therapy through a 10 x 10 field, in divided doses of 300 r each, showed slight softening. The lesions were so numerous, however, that they could be counted only with difficulty. Many were barely perceptible and others appeared to be mere discolorations or spongy elevations. The attempt to treat them individually was therefore abandoned.

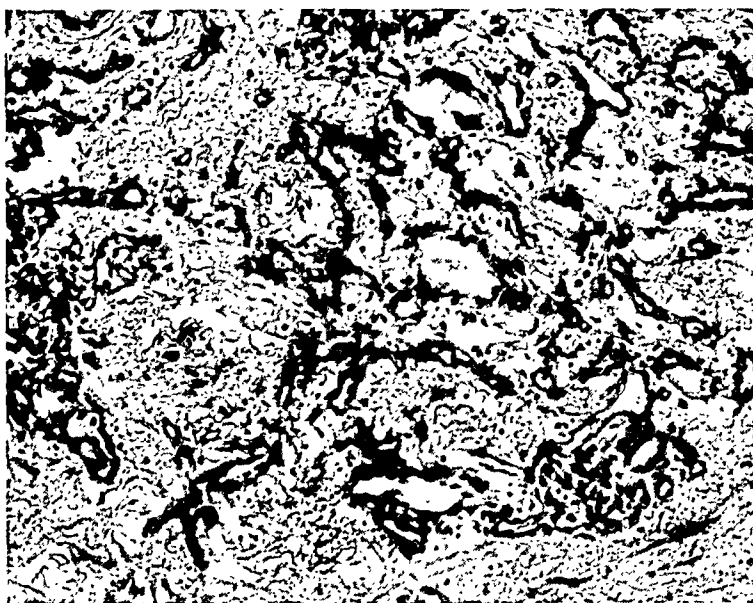


FIG. 2.—Photomicrograph of the primary tumor of the right breast, showing a fairly characteristic hemangioma.



FIG. 3.—Photomicrograph of the metastatic nodule in the scalp, showing definite sarcomatous changes.

The patient left the hospital and did not return for five months. At this time the left breast was tremendously enlarged, discolored, and tense (Fig. 4). A palliative partial mastectomy was done. A large part of the tumor had invaded the chest wall and mediastinum. The histologic structure was similar to that observed in the scalp tumor; mitotic figures were fairly numerous. The patient was discharged and three months later died at home, three years after the first breast tumor was noted. An autopsy was not performed.

Borrmann,¹ in 1906, reported the first case of this previously unrecognized

form of angioma, that of a female, aged 26, who had developed a walnut sized tumor in the right breast. It was excised a few months later but recurred five times during the following year, each recurrence being excised in turn. In addition a mass appeared in the scapular region which was also removed. The patient died 21 months after the tumor was first noticed, 17 months after excision. Autopsy showed another recurrence in the region of the primary site and a similar mass in the left buttock. Both lungs were filled with small hemangiomatous masses and the pleural cavities contained bloody fluid. The original tumor was not available for study, but all the recurrences and the metastases showed a structure fairly characteristic of



FIG. 4.—Appearance of patient two years and three months after her first admission, showing the numerous metastases in the skin and the marked involvement of the left breast.

telangiectasis or simple angioma. Borrmann emphasized the fact that there was nothing to distinguish any of them from benign hemangiomata without metastases.

The second case, reported by Shennan,² in 1914, was that of a female, aged 23, with a six year history, beginning with hemoptysis and later followed by splenomegaly, hemothorax and ascites. During her illness three small tumors appeared on the skin, one of which was excised and proved to be a cavernous hemangioma. At autopsy tumors of similar histologic structure were found in the spleen, lungs, thymus, bone marrow, liver and lymph nodes. The primary source was evidently in the mediastinum. In none of the organs did the histology remotely suggest sarcomatous change. While it cannot be denied that the internal tumors might possibly have been

slowly growing multiple benign angiomas, the skin lesions were presumably metastatic, and it is probable from the history that the larger tumors were, also.

Ewing³ discusses the case of a middle aged woman with a bulky cavernous hemangioma of the breast with numerous metastases to the skin and lungs. The structure was similar to that described by Borrmann.

Geschickter and Keasbey⁴ mention the case of a 62 year old man with angiomatous masses in both iliac fossae, lungs, pleura and spleen, all of which showed the histologic structure of an apparently benign angioma.

DISCUSSION.—Although varying in structure—Borrmann's case was a simple angioma; Ewing's was "quite similar"; Shennan's was a cavernous hemangioma; Geschickter and Keasbey's consisted of tightly packed spindle cells surrounding sinuses lined by endothelium—these four cases conform to the definition of this group: that is, they are metastasizing angiomas in which both the primary and secondary tumors are seemingly histologically benign. For this reason, they should be separated from two other large groups of hemangiomas. The first of these are the definitely malignant metastasizing hemangiosarcomata—*e.g.*, the cases reported by Pick, Stamm, Ullman, Kopf, Theile, and Jores (mentioned by Sonntag⁸), the cases of Wright,⁹ Hall,¹⁰ and others. The second are the multiple (not metastatic) benign hemangiomas, particularly those occurring in children, which by local invasive growth, location or hemorrhage may cause death, among them the cases reported by Homans,¹¹ Jaffé,⁵ Wollstein,⁶ Taylor and Moore,⁷ and many others.

Borrmann discussed his case under the title of "Metastasenbildung bei histologisch gutartigen Geschwülsten" in order to clearly emphasize the vagueness of the boundary between benign and malignant tumors. He felt that the presence of metastases could no more be used to determine definitely the benign or malignant character of a process than, for example, the absence of a capsule, invasiveness, or rapid growth: these, we know, are not exclusively benign or malignant properties. Shennan, on the other hand, although agreeing with Borrmann with reference to the classification of these angiomas, calls attention to another problem which we consider more important; *viz.*, whether the histologic criteria, rather than the clinical, are not at fault.

Ewing feels that this group of angiomas is a borderline entity, "cavernous or more cellular angiomas possessing certain peculiar features of malignancy." Livingston and Klemperer¹² describe the histology of a single hemangioma invading the scalp. They considered the stroma, which simulated that of Borrmann's case, to be undifferentiated mesenchyme rather than simple connective tissue. They believed that the tumor reported by them and those reported by Borrmann, Shennan and Ewing possess similarities which justify their inclusion in a group by themselves—as malignant mesenchymal angiomas. Since the outstanding clinical feature of Livingston and Klemperer's case was the local invasive growth, their hypothesis, if true, might well explain the invasive properties not infrequently seen in solitary

angiomata. Their case, however, does not show the essential feature characterizing the other three: namely, the production of metastases. We are not certain, therefore, that the conclusions they have drawn from their case can be applied to these others.

Wright⁹ divided metastatic hemangiomata into two general groups. He differentiates those with a histologically benign structure (cases of Shennan, Borrmann, and Ewing) from those with a histologically malignant structure (cases of Theile, Jones, Langlans, and his own, all of which were hemangiosarcomata of the spleen with metastases to the liver and other organs). He points out that the common feature of both groups was the formation of metastases, the histologic structure of which was similar to that of the primary tumor. In none did the primary benign hemangioma give rise to metastases with structural characteristics of malignancy.

It seems to us that the case we are reporting is a connecting link between the four cases cited in the literature and the true angiosarcomata. Ours is evidently an example of an apparently histologically benign tumor giving rise to malignant metastases. To assume that this is a case of multiple tumors one would have to admit that there were numerous hemangiomatous rests, such as Ribbert (quoted by Borrmann) describes, which began to grow under the influence of local or general factors. If this were true one would expect these secondary tumors to have been discernible either at the same time as the original tumor or certainly within a shorter period than one year. Since it is highly improbable that this is a case of multiple tumors, but rather that the lesions that appeared following the original breast tumor were really metastases, we must conclude that we are dealing with a process which was malignant from the onset and that the primary tumor, in spite of the absence of histologically malignant properties, was not benign. We feel that because the histologic structure of our case is very similar to the quoted cases, especially those of Borrmann and Ewing, it is probable that the latter were also primary malignant tumors. This is in agreement with Shennan's concept that it is the occurrence of metastasis which should be the deciding factor and not the histologic features.

In addition to its bearing on the classification of these angiomata, our case is also of interest because an opportunity was afforded to study the response of these tumors to various forms of treatment—surgical excision, suberythema doses of superficial roentgen rays, divided dose deep therapy, massive dose of intermediate therapy, and various combinations of these. In using suberythema doses of long wave length roentgen ray our aim was the production of an obliterating endarteritis in the tumor, comparable to the commonly accepted method of treating hemangiomata of the skin with small doses of radium at long intervals (Roesler,¹³ Kaplan,¹⁴ Baensch¹⁵). In using the deep and intermediate therapy an attempt was made to actually destroy the lesion. The response of the tumor, in spite of the large doses used for some of the lesions, was only temporary. There is very little doubt, therefore, that these tumors are highly resistant to radiation.

Before leaving the subject of radiation the remote possibility of the roentgen ray itself producing sarcomatous changes in the treated tumors should be mentioned. Sarcomatous degeneration as the result of radiation is extremely rare, and a *post hoc ergo propter hoc* element in the few reported cases cannot be excluded (Livingston and Klemperer). No case of such degeneration has ever been reported in a benign hemangioma treated by roentgen ray or radium, although radiation treatment of these is quite common. Other factors, such as the small amount of radiation which the masses in the scalp and left breast (both hemangiosarcoma) received, further reduce this remote possibility.

SUMMARY.—(1) So called "benign metastasizing hemangiomata" are defined and their classification and significance are discussed.

(2) An unusual case of an angioma of the breast with benign histologic characteristics which produced definitely malignant metastases is reported. Because of the histologic similarity of the primary tumor in this case to reported cases of so called "metastasizing benign angioma" the benign character of the latter must be questioned.

(3) The response of this tumor to various forms of radiation shows it to be highly radioresistant.

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THE IMPORTANCE IN SURGERY OF THE BLOOD CIRCULATION TIME

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IN HIS work, the surgeon is confronted with two problems. First, he has to select the type of procedure best suited to the disease from which the patient is suffering, and secondly, he has to evaluate the risk of the procedure on the individual patient. In other words, to estimate as exactly as possible all the factors entering into the conception, "surgical risk." Of these factors, the function of the heart and kidneys is of paramount importance. In the presence of pronounced lesions of these organs, the estimation of their function is comparatively easy and the surgeon is guided by the clinical examination and routine laboratory tests. A large number of patients, however, are on the borderline of the class considered "poor surgical risks." In these, neither examination of the heart nor routine urine and blood examinations will disclose the impending danger of latent cardiovascular insufficiency. These cases are responsible for a large percentage of the mortalities, both in elective and emergency surgery.

Any method permitting a better evaluation of this latent cardiovascular disability should be a welcome addition to our diagnostic and prognostic armamentarium. Prerequisites for any additional method used for this purpose must be reliability and simplicity. The quest for such additional methods led us to the use of blood circulation time estimations.

Having passed through an evolutionary process of its own, the estimation of the velocity of blood circulation is now recognized as an accurate and useful diagnostic measure by many research workers and clinicians.^{1, 2, 3, 4, 5}

The technic of the procedure has been simplified to a great extent, and as used by us the test can be applied to great advantage by any one proficient in intravenous medication. It occupies less time than a routine blood count and employs no other instrumentation than an hypodermic syringe and several solutions as mentioned under TECHNIC.

We have conducted the present study on circulation time with the following desiderata in mind.

(1) As a means of studying the effects of spinal anesthesia, morphine administration, and abdominal distention, on the velocity of blood flow through the lungs and their possible relationship to postoperative pulmonary complications.

(2) As an aid in cases where a differential diagnosis between cardiac or infradiaphragmatic disease must be established.

(3) As an aid in evaluation of the patient as a surgical risk.

(4) For the purpose of studying the change in circulation time in definitely established pulmonary affections and the relationship of these changes to the pulmonary complications.

TECHNIC.—Essentially, the technic as described by Fishberg, Hitzig and King⁴ was followed throughout in this study. The antecubital vein was punctured by a No. 19 gauge needle, to which a three way adapter and syringe are attached. To the side outlet of the adapter, a graduated pipette is attached, into which the blood is allowed to flow to establish the venous pressure (Taylor, Thomas and Schleiter⁶). To assure accurate readings of the venous pressure values, the elbow must be supported at a level so that the vein is 5 cm. below the anterior surface of the sternum at the fourth rib. The pipette is rinsed with sodium citrate solution to prevent clotting of the blood. Following this estimation and without removal of the needle, a solution of 2½ Gm. of soluble saccharin dissolved in 2.2 cc. of distilled water (this solution is freshly prepared in a test tube and sterilized over an alcohol flame) is injected into the vein. The time elapsing from the moment of the injection up to the time the patient experienced a sensation of sweetness on his tongue is measured by a stop watch and recorded as arm-to-tongue or saccharin time. This represents the time it takes a particle of blood to pass from the vein injected to the capillaries of the tongue. It is the sum total of vein-to-heart time, the intracardiac time, the intrapulmonary time and the heart-to-tongue capillary time. A second syringe containing 5 minims of ether and 5 minims of saline is then applied to the adapter and the contents injected into the same vein. The breath of the patient is smelled by the observer, and the time recorded when ether is first noticed in the exhaled air. This is known as "ether time" and represents the vein-to-heart plus right heart-to-lung time.

The tests were all conducted at resting conditions and checked by two observers. The saccharin test, though subjective in nature, is so very definite that even the most unintelligent patient cooperates satisfactorily. Repeated readings in 23 normal individuals showed a maximum variation in saccharin time of 3.5 seconds and an average variation of 1.4 seconds. The maximum variation in the ether time was six seconds and the average variation of 1.5 seconds.

Normals established in 70 readings on 42 surgical patients admitted to the wards of the Coney Island Hospital for various conditions such as appendicitis, gallbladder disease, fractures, *etc.*, and whose ages varied from adolescence to advanced middle age, gave 10.7 seconds as the average normal saccharin time and 6.3 seconds as the average normal ether time.

The variations in this group were as shown in the table on p. 462.

Blumgart and Weiss,⁷ measuring the velocity of blood flow in normal individuals, showed that the maximum variation in repeated circulation time measurements on the same individual did not exceed three seconds. It has been further established that there is no critical age beyond which the

SACCHARIN TIME			ETHER TIME		
Seconds		No. of Readings	Seconds		No. of Readings
6	.....	2	2	.....	1
7	.....	3	3	.....	3
8	.....	10	4	.....	6
9	.....	10	5	.....	12
10	.....	14	6	.....	12
11	.....	9	7	.....	26
12	.....	4	8	.....	3
13	.....	8	9	.....	3
14	.....	4	10	.....	3
15	.....	2	11	.....	1
16	.....	1	12	.....	0
17	.....	2	13	.....	0
18	.....	1	14	.....	0
<hr/>			<hr/>		
10.7	Average.....	70	6.3	Average.....	70

velocity of blood flow changes, and that the elevation of arterial blood pressure does not influence the circulation time of the blood.

Increase of Speed.—Increase of speed of blood flow occurs in:

(1) Exercise.—From 50 to 100 per cent. Hence all tests must be made under conditions of physical rest.⁸

(2) Thyrotoxicosis.—The speed being roughly proportional to the increased metabolic requirements.⁹

(3) Marked Anemia.—Primary and secondary, roughly in proportion to the degree of the anemia.¹⁰

Decrease in Speed.—Decrease in the velocity of blood circulation, or conversely, increase in circulation time occurs in:

(1) Myxedema.¹¹

(2) Polycythemia.¹⁰

(3) Various types of heart disease. When present it reflects the disfunction due to myocardial involvement. This is true of any kind of heart disease, be it rheumatic, luetic, arteriosclerotic or hypertensive. Prolongation of the circulation time is due commonly to the insufficiency of the left heart with pulmonary engorgement. This retardation of the velocity of the blood circulation as measured by the "Saccharin Test" may occur in cardiac patients *before* other symptoms are manifest or subjective disturbances noticed.¹³ In such cases, the measurement of the circulation time is the only means of discovering the cardiac lesion. In a few exceptional cases of pronounced heart failure, normal figures for circulation time have been obtained.¹³

(4) Local obstructive factors in the circulatory pathway, such as mediastinal or cervical tumors, aortic aneurysms, *etc.*, must be eliminated in evaluating increased circulation time readings.

Circulation Time as Effected by Operation.—Forty-two patients, of whom all but three were subjected to major surgical procedures, as indicated in

Table I, were fair operative risks as judged by the usual clinical and laboratory procedures.

TABLE I

OPERATIONS	No.
Appendectomy.....	14
Hysterectomy.....	6
Cholecystectomy.....	8
Hernioplasty.....	5
Thyroidectomy.....	1
Cholecystectomy-hysterectomy.....	1
Anterior-posterior colporrhapy.....	1

The age distribution was as follows: 15 to 30 (17); 30 to 40 (6); 40 to 50 (17); 50 to 60 (2). All the operations were performed under spinal anesthesia. There was uniformly a mild temperature reaction on the first day. This was associated with some acceleration of the pulse rate. All patients were adequately morphinized, so there was a minimum of postoperative discomfort. In a moderate number of instances there was mild abdominal distention on the first postoperative day. Snug, and in some cases tight, abdominal dressings were applied in all cases unless there was some definite contra-indication. Repeated postoperative C. T. readings were made in 23 instances, (24 to 36 hours postoperatively) and in 12 cases only a single reading (12 to 24 hours postoperatively) was made. Of the 12 single postoperative readings made, all were within normal limits. In the 23 cases in which pre- and postoperative readings were made, no significant variations could be demonstrated. The maximum variation in S. T. was 3.5 seconds. The average 1.5 seconds. The maximum ether time variation was six seconds (one case). The following inferences can be drawn from the study:

(1) Repeated C. T. readings in an individual in whom there is no intrathoracic disease or local obstructive factor, are relatively constant or show only minimum variation.

(2) Laparotomy. Upper or lower has no effect on C. T.

(3) Morphine in clinically effective doses has no effect on C. T.

(4) Slight elevation of pulse rate and temperature. Such as are encountered postoperatively, have no effect on C. T.

(5) Moderate abdominal distention or tight abdominal dressings have no effect on the C. T.

(6) Age, *per se*, has no effect on C. T.

Circulation Time in Spinal Anesthesia.—Six cases are presented (Table II) where the C. T. was recorded before and within half an hour after the administration of spinal anesthesia. Preoperative blood pressure was normal in this group. As a result of the anesthesia, there was a fall in blood pressure from an average of 113/88 prespinal to 92/58 postspinal. The average pulse rate changed from 88 to 90. Conclusions: No significant variation in the C. T. occurred as a result of the spinal anesthesia. These findings are of interest particularly in view of the postspinal fall in blood pressure and

changes in pulse rate. Further observations which will permit more accurate deductions on this all important phase are being conducted.

TABLE II
DIRECT EFFECT OF SPINAL ANESTHESIA

Case No.	Age	Operation	Prespinal Readings				Postspinal Readings (within ½ hr.)			
			Pulse Rate	Blood Press.	S.T.	E.T.	Pulse Rate	Blood Press.	S.T.	E.T.
1	20	Appendectomy	90	128/80	10.	7.	110.	98/50	8.	4.
2	34	Hysterectomy	80	136/90	10.	6.	100.	82/60	8.	6.
3	35	Cystocele operation	80	114/82	12.	8.	90.	114/82	11.	7.
4	32	Bilateral hernioplasty	90	148/110	13.	7.	74.	70/52	15.	8.
5	32	Cystocele and rectocele op.	80	130/80	12.	9.	90.	90/60	11.	9.
6	24	Exploratory laparotomy	110	130/90	18.	8.	80.	94/52	9.	7.

Circulation Time and Differential Diagnosis.—In the six cases analyzed in Table III, the C. T. was well above normal. In five of the cases, the diagnosis of peptic ulcer was made on admission to the hospital. Further investigation revealed the presence of arteriosclerotic heart disease, in two cases (1 and 4) and completely negative findings in the gastro-intestinal tract.

Cases 2 and 3 had acute coronary arterial disease (confirmed by autopsy) with coincident perforation of gastric ulcers. Case 3 was operated upon for the gastric lesion. Death occurred one hour after operation. Autopsy revealed a fresh myocardial infarct.

Case 5 died 36 hours after admission. No operation. Roentgenogram showed an enlarged heart. Electrocardiogram showed left ventricular hypertrophy with premature contractions. The abdominal signs cleared up after 12 hours' observation. The cardiologist (Doctor Sigler) was of the opinion that the heart was responsible for the symptoms and the sudden death. An autopsy was not obtained.

Case 6 had complaints typical of gallbladder disease of several months' duration. The gallbladder series was negative. The gastro-intestinal tract was negative except for marked periduodenal adhesions. The patient appeared to be in excellent physical condition. Exploratory laparotomy and cholecystectomy were performed under spinal anesthesia. Towards the end of the operation (one-half hour) the heart suddenly stopped beating. With continued respiration, the patient was revived by stimulation, death ensuing several hours later. Critical analysis of the case made us believe that death was caused by a cardiac accident, probably coronary occlusion. Autopsy was not obtained.

In each of these six cases, the prolonged C. T. proved to be of great significance from the diagnostic standpoint. All of the patients were acutely sick on admission; histories and physical findings suggested upper abdominal catastrophes. Immediate consultations with a cardiologist, and electrocardiographic studies permitting a complete investigation of the heart, would have

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TABLE III
CIRCULATION TIME AS A DIAGNOSTIC MEASURE

Case No.	Age	Symptoms	V.P.	S.T.	E.T.	Pulse Rate	Blood Pressure	Roentgen ray	Heart	Admission Diagnosis	Final Diagnosis	Clinical Course
1	42	Severe epig. pain and G-I complaint	6	21	10	80	110/80	Chest and G-I	P. X. neg.	Penetrat. ulcer	Coronary disease	Developed typical coronary disease
2	40	Collapse; rigid abdomen	0	31	11	120	neg.; Wass. ++			Ruptured ulcer	Rupt. G. ulcer; coronary occlusion	Died, autopsy: perforated ulcer and coronary occlusion
3	45	Rigid upper abdomen; pain 5 days' duration	6	23.5	9	..	70/50	None	Severe shock; tones indistinct	Ruptured ulcer	Coronary disease	Developed typical coronary disease
4	68	Upper abdominal pain; perforated viscus?	7	22	11	120	96/79	None	Size normal; no murmur; tones muffled	Perforat. ulcer	Perforat. ulcer; coronary occlusion	Death 1 hr. p.o. rupt. duoden. ulcer, coronary occlusion
5	54	Upper abdomen tender with spasm; rupt. ulcer?	15.5	27	17.5	80	116/84	Flat film	P. X. neg.	Perforat. ulcer	Myocardial disease	Abdominal symptoms subsided; improvement under cardiac regimen
6	50	Right upper abdominal pain; acute G-B?	12	21	9	76	92/70	G-B. series neg., periduo-denal adhes.	Ecg.-L. Vent. premature contr.	Perforat. ulcer	Luetic myocarditis; aneur. aorta	Died 36 hrs. later; no evidence of intra-abdominal disease
										G-B. disease	Cardiac failure	Cholecystect.; G-B. no pathology; heart stopped beating on table. With cont'd respiration resuscitated. Death 6 hrs. later

delayed surgical therapy that seemed imperative at the time of admission for several hours. Examination of the C. T., however, gave us a very definite idea as to the presence of myocardial dysfunction, regardless as to whether or not coincident intra-abdominal disease was present.

Significance of Postoperative Changes of Circulation Time.—In the cases outlined in Table IV, an interesting feature may be observed. Preoperatively, the C. T. was normal in most of the cases (except Case A). Yet, postoperatively, a definite rise in C. T. was observed. All of these cases developed pulmonary complications.

Case 1.—A female of 57. Radical mastectomy for carcinoma of the breast. Preoperative roentgenogram of chest, negative. S. T. 8, 24 hours later S. T. was 20. Four days later, fluid appeared in left chest. One month later, chest clear; S. T. 14.

Cases 2 and 7.—These are of particular interest. Preoperative C. T. normal. On the first postoperative day, both showed marked slowing of C. T. Neither had clinical signs of pulmonary complications. Roentgenograms at this time revealed areas of infiltration and congestion. Both made uneventful recoveries with the return of C. T. figures to normal.

Cases 3, 4, 5, 6 and 8.—All had definite postoperative pulmonary complications, diagnosed clinically and roentgenologically. The preoperative C. T. was normal in all of them. A definite and marked increase in the C. T. was observed with the onset and during the course of the pulmonary symptoms, in Cases 4 and 6, both of which had pulmonary atelectasis. The C. T. returned to normal following resolution of the pulmonary process.

In Case 8, there was no increase of the C. T., notwithstanding the presence of extensive pulmonary involvement. This, however, may be explained by the fact that the patient was in an oxygen tent most of the time receiving a ten per cent mixture of oxygen and carbon dioxide. He developed a most intensive hyperpnea (resp. 40 to 50) a condition which, normally, will increase the speed of circulation.

It is of interest to note in this connection that pulmonary atelectasis is practically unknown following operations for toxic goiter, also that the velocity of blood flow is greatest in this disease. Contrasting these two facts, it seems probable that a definite relationship exists between the slowing of the C. T. and the development of pulmonary atelectasis.

We would like to comment on several other interesting findings:

Case A.—A man of 42 sustained a chest trauma, which caused a fracture of several ribs. Pleural effusion with fever and cough developed. The C. T. at this time was S. T. 20; E. T., 12. Six days later, when the symptoms subsided, and the temperature was normal, the S. T. was 14 and the E. T. 8.

Case B.—Man, aged 40, with a postpneumonia empyema. S. T. 18; E. T. 10. After drainage of the empyema, S. T. 17; and E. T. 8.5. This lack of improvement in the C. T. prompted us to have an electrocardiogram made. This showed definite myocardial damage, which may well have been the cause of the constantly high S. T.

Case C.—An obese female of 34, with a blood pressure of 128/78, had an S. T. of 30, and E. T. 12, venous pressure 8. Because of this finding, roentgenograms of the chest were taken. They revealed bilateral chronic bronchitis and bilateral upper lobe fibrosis.

TABLE IV

RELATION OF CIRCULATION TIME READINGS TO PULMONARY COMPLICATIONS

Case	Age	Diagnosis	Preoperative			Postoperative Readings						Roentgenologic Findings	Temp.	Pulse	Blood Pres- sure		
			V.P.	S.T.	E.T.	V.P.	S.T.	E.T.	V.P.	S.T.	E.T.						
1	57	Ca breast	7	8	4	24 hrs.	20	7	1 mo.	10	14	14	8/30 Fluid in chest 9/6 Left pleura—fluid			150/92	
2	48	L. ing. hernia	7	14	7	8/17	8.5	25	12	8/20	10	13	8	Areas of pneumonic infiltration; no clinical signs	96°	100	
3	42	Appendicitis	8	8	5	48 hrs.	21	8.5	5 days	8	19	8.5		Bronchial pneumonia at base of right upper lobe	102°	100	145/90
4	21	Hernia				7/21	5	22	10	7/25	14	20	8	Right lobe atelectasis	102°	99	120/80
5	36	Acute append., chr. bronchit.				7/26	10	10	5	7/28	12.5	15	9	Bronchial pneumonia — lower left lobe	103°	100	
6	20	Atelectasis of lung				3 days		23	7								
7	43	Cardiospasm	4	10	4	8/1	16.5	24.5	7.5	8/3	3.5	10	4.5	Cardiospasm; bilateral pulm. congestion and some bron- chial changes	102°	120	122/80
8	45	Strangulated hernia						12	9					10/24 chest neg. 10/29 Dysp- nea and cough. Bilateral pneumonia congestion and bronchitis. Pneu. infiltra. both lower lobes and r. upper lung, mid portion	101°	90	
A	42	Multiple rib fractures	(After accident)				9	20	12	6 days	6	14	8	Evidence of pleural effusion			140/80
B	40	Empyema	12	18	10		11	17	8.5					Empyema. EcG: evidence of myocardial damage			
C	34	Rupt. int. meniscus	8	30	12									Chest: bila. chronic bron- chitis—bilat. upper lobe fi- brosis	99°	100	128/78
D	20	Pneumonia	5	11	6									Rt. lower lobe pleuropneu- monia	104°	120	125/70

TABLE V
CIRCULATION TIME AS A PROGNOSTIC INDICATOR

Case	Age	Diagnosis or Leading Symptoms	V.P.	S.T.	E.T.	Pulse	Temp.	Hb.	Blood Pressure	Roentgen Ray	EcG.	Admission Diagnosis	Final Diagnosis	Clinical Course
1	45	Abd. pain, rigid abd. Substidence of symptoms in two days	6	23.5	9	—	—	—	—	—	—	Perforated ulcer	Perforated ulcer, myocardial infarct.	Death 12 hrs. postop. from myocardial infarction
2	36	Recurrence on fifth day postoperative Vaginal bleeding, fibroid uterus, cystocele and rectocele	Preop. 7.5	29	16	80			140/70	Slight chr. bronchitic changes	1st Normal 2nd Definite evidence of myocardial damage	Fibroid cystocele, rectocele	Myocardial degeneration, coronary sclerosis	In view of prolonged C.T. only plastic done (spinal); p.o. course characterized by pre-cordial pain and medical shock
3	50	Questionable G-B disease	12	21	9	80			92/70			G-B disease	Myocardial failure	Died soon after oper. (heart stopped on table)
4	47	Adenoma-thyroid	20	22	8	70			180/100			Adenoma, thyroid	Adenoma, thyroid, myocardial failure	Sudden death, 12 hrs. postop. No local cause for death
5	40	Ruptured ulcer, and coronary art. thrombosis. Patient in collapse on admission	0	31	11	120			70/50	Chest—neg.		Ruptured ulcer—coronary art. thrombosis	Ruptured ulcer, coronary thrombosis	Death 12 hrs. after adm. No surgery. Autopsy
6	73	Strangulated hernia	Preop. Postop.	30 25	18 8	100	99.6°		185/95		Evidence of myocardial damage	Strangulated hernia, coron. art. disease, myocard. degener.	Same	Death fourth postop. day. Myocardial failure. Pulmonary edema
7	50	Ca. stomach	27			Proper.			84/62	Gastric Ca.	Severe myocardial disease	Ca. stomach	Ca. stomach—myocardial failure	Gastro-enterostomy and death in 24 hrs.
8	67	Strangulated umbilical hernia	8	33	10	80 100	101.0°		170/110			Strangulated umbilical hernia	Myocardial failure, cerebral accident	Patient died suddenly when out of bed—2 wks. Postop.
9	35	Fibroid uterus	7	13	6	80			130/80			Fibroid uterus	Same	Uneventful recovery 2 stage operation.
10	45	Ca. rectum	7	8	7	76		50%	140/80			Ca. rectum	Same	Uneventful. Postoperative course

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11	50	Ca. uterus	9	9	8	72	N.	170/92	Ca. uterus	Same	Good operative reaction
12	40	Acute cholecystitis 24 hrs. postop.	13	10	7	100	101°	114/70	Acute cholecystitis	Same	Prolongation of s.t., but good reaction to operation, hrt. not investigated
13	48	Fibroid uterus	12	10	6	76	98.6°	120/70	Fibroid uterus	Same	Hysterectomy, uneventful recovery
14	45	L. inguinal hernia hypertension	11	9	7	70	99°	170/108	Hernia	Same	Uneventful postoperative course
15	43	Common duct stone (very ill), jaundice	7	12	7	100	102°	75%	Cholecystectomy, common duct drainage	Same	Uneventful recovery
16	46	Acute cholecystitis	6	18	9	76	99°	110/70	Cholecystectomy, appendectomy	Same	Cholecystectomy — uneventful recovery
17	58	L. inguinal hernia, emphysema, cyanosis	5	16	10	68	98.6°		L. ing. hernia		Recovery and slight pulmonary complication. Excellent prognosis
18	57	Ca. breast, acute pleurisy and effusion	7	8	4	80	98.6°	150/90	Ca. breast	Ca. breast and postoperative pleurisy	Uneventful recovery — complicated by pulmonary complication
19	40	Fibroid gallstones 24 hrs. postop.	5	9	5	76	99°		Hysterectomy, salpingo-oophorectomy, appendectomy	Same	Uneventful recovery following cholecystectomy, hysterectomy and appendectomy
20	28	G-B disease	—	15	—	80	98.6°	128/80	Cholecystectomy, appendectomy	Same	Cholecystectomy, uneventful recovery
21	50	Hernia	8.5	8	7	80	99.6°	118/90	Hernioplasty and spinal anesth.	Same	Uneventful recovery
22	42	Cholecystitis, acute empyema	6	8.5	7.5	100	101.6°		Cholecystectomy, appendectomy	Same	Cholecystectomy, uneventful recovery
23	43	Ca. rectum	10	7	11	72	98°	70%	Ca. rectum	Same	Reactive well to surgery
24	40	Hysterectomy, appendectomy	9	11	5	N.	N.	130/80	Hysterectomy, appendectomy	Same	Uneventful recovery
25	31	Adenoma thyroid 5 days postoper.	11	22	7				Adenoma thyroid		2 histories of prolonged c.t. where outcome was favorable

Case D.—A young man of 20, with a 24 hour history of right upper abdominal pain and cough. Temperature, 104°; pulse, 120. S. T. 11; E. T. 6, and venous pressure 5. Roentgenologic examination revealed a pleuropneumonia at the right base. This involvement was not associated with prolongation of the C. T.

Comment.—Eight cases with postoperative pulmonary complications were observed. These were confirmed in all instances roentgenologically and clinically in six. In seven of them, there was a definite prolongation of the C. T. In four nonoperative cases, in which pulmonary pathology was observed, a prolongation of the C. T. was observed in three. Our observations do not justify us, at the present time, in expressing a definite opinion as to the sequence of events, that is; whether the slowing of the C. T. precedes the establishment of the pulmonary complications or whether it is a result of the action of the pulmonary stasis on the heart muscle. These findings are at variance with those of other observers who found no changes in cases of pulmonary tuberculosis or lobar pneumonia. However, the mechanism involved in postoperative pulmonary complications is probably of a different nature than that involved in a classic pneumonia.

We have grouped the postoperative cases under one heading recognizing the differences in the clinical picture. We feel that these clinical entities may be different stages of one process. If the prolonged postoperative C. T. be an indication of clinically unrecognizable left heart weakness, therapeutic measures such as cardiac stimulation and hyperventilation of the lungs can be successfully employed to prevent the development of serious pulmonary complications.

Prognostic Value of the Circulation Time Test.—The preoperative estimation of myocardial sufficiency is of greatest value to the surgeon. The following 20 cases show the value of this simple test in the field of preoperative "risk" estimation. The first eight cases presented are illustrative of the bad postoperative prognosis that frequently accompanies prolongation of C. T.

Case 1.—A male, 45 years old, in apparent good health, with negative heart findings except for slightly muffled heart sounds. Clinical findings: Symptoms of ruptured gastric ulcer, C. T. 23.5 seconds. Simple closure of perforation. Death, six hours later. Autopsy: Fresh myocardial infarction.

Case 2.—A young woman of 36, mild diabetic, referred to surgery for hysterectomy and vaginal plastic. No cardiac complaints or pathologic findings. C. T. 29.5 seconds. Because of the increase in the C. T., only the vaginal plastic was done, under low spinal anesthesia. Immediately after operation, patient was seized with severe precordial pain, with radiation down left arm. Cardiovascular collapse. Electrocardiographic studies during convalescence revealed considerable myocardial damage.

Case 3.—Well preserved man of 50, operated on for gallbladder disease. C. T. 21.5 seconds. Death eight hours postoperative, apparently from cardiac collapse.

Case 4.—Woman of 47, with recurrent adenoma of thyroid, nontoxic. C. T. 22.3. Death, 12 hours postoperative. No evidence of hemorrhage or laryngeal obstruction. No autopsy.

Case 5.—Man, 40 years old, admitted to hospital with rigid abdomen and signs of vascular collapse. Complaint of substernal pain of 24 hour's duration radiating into

the epigastrium. No operation was performed. S. T. 31; E. T. 11. Death ten hours after admission. Autopsy findings: Ruptured duodenal ulcer and coincident myocardial infarction.

Case 6.—Man, 73 years old. Hypertensive. Strangulated direct inguinal hernia. S. T. 30; E. T. 18. Operation under local anesthesia. No shock. Death on fourth postoperative day with signs of progressive myocardial disease.

Case 7.—Man, 51 years old, with carcinoma of stomach. General condition appeared to be poor. S. T. 27. Gastro-enterostomy. Death, two days later. No evidence of peritonitis.

Case 8.—Man, 67 years old. Admitted with strangulated umbilical hernia, but in apparent good general condition. S. T. 33; E. T. 10. Uneventful postoperative course. Death on the fourteenth day, when patient was up and about.

Five of these eight cases appeared to be good risks, clinically, and yet succumbed postoperatively.

Cases 9 to 24 all had normal C. T. readings. These cases were subjected to major surgery of varied types as shown in Table V. The age group was similar to that of the first eight cases detailed. In the main, these patients were good risks clinically, though a few appeared to be bad risks. No mortality occurred.

Case 25.—Adenoma of thyroid in a woman 31 years old. S. T. 22, on admission. Five days postoperative, S. T. 10. Recovery uneventful. The possibility that the prolonged C. T. preoperatively was related to the adenoma of the thyroid has to be taken into consideration.

Comment.—The above cases were consecutive ones and the conclusion seems inevitable that the mortality in patients with prolonged C. T. is very high. Though some of these patients were obviously poor risks, others (and these constitute a large number) would clinically fall into the group of "fair surgical risks."

Early failure of the heart, particularly the left heart, is not always apparent on clinical examination. These patients may become the subjects for major surgical procedures, elective or mandatory. Prolongation of the C. T. may be the only indication of their precarious condition, and its recognition a life-saving factor in our operative endeavors. Where surgery is imperative, the surgeon is forewarned as to the status of his patient and proceeds accordingly. In elective cases, appropriate therapy such as rest, digitalization and weight reduction will be followed by a better prognostic outlook. It is natural that this test is particularly valuable in the older group.

Venous Pressure Studies.—Routine V. P. readings were performed on the patients subjected to these circulation tests. The method used was that of Taylor, Thomas and Schleiter.⁶ Thirty-two readings on as many normal subjects varied from 5 to 15 cm. as follows:

In the instances of greatest postoperative change, no significant clinically recognizable events occurred. In a group of cases where C. T. readings were of great value in differentiating or establishing cardiac disease in the presence of abdominal symptoms, V. P. readings were of little aid. In eight cases where the C. T. was markedly prolonged, the V. P.'s were 6 in two

Cm.	Patients
5	1
6	4
7	6
8	7
9	2
10	3
11	1
12	5
13	1
14	1
15	1

Forty postoperative V. P. readings showed the following:

Cm.	Patients
3	1
4	4
5	2
6	2
7	9
8	4
9	4
10	4
11	2
12	2
13	2
14	2
16	2

In 24 instances, the pre- and postoperative V. P. readings showed the following changes:

Variation in Cm.	Instances
0	7
1	5
2	3
3	1
4	3
5	1
6	2
8	2

cases; 7 in one; 11 in one; 0 in one; 15 in one; and 20 in one case. Thus, in only three instances out of eight cases of definite cardiac disease, was there any definite change in the V. P. record. The patient who showed a V. P. of 0 was in pronounced shock. The patient in whom a reading of 15.5 occurred had myocardial changes and subsequently died from a cardiac lesion. The patient in whom a reading of 20 cm. was recorded had a large substernal thyroid adenoma and had a C. T. of 22. One case with a V. P. of 17 cm. died of pulmonary embolism on the 5th postoperative day. In two cases of postoperative pulmonary complications, there was a marked rise in the V. P.

Comment.—Venous pressure readings do not have the value that S. T. readings have for the surgeon. Unless the right side of the heart is in failure or latent failure, or there is a vascular collapse, the changes fall within normal range. Operative procedures do not seem to have any effect on the V. P. Changes in the V. P. may occur in postoperative pulmonary complications. It seems possible from our studies that patients with high V. P.'s may be predisposed to embolic processes in the lung or elsewhere. If further studies substantiate this supposition, it may become possible to segregate these patients in order that immediate embolectomy be performed when and if suspected and expected embolism occurs.

CONCLUSIONS

A study of C. T. on a number of surgical patients is presented. It has been shown that the test for establishing the C. T. is simple and accurate. It is applicable as a routine measure for differential diagnostic purposes in upper abdominal and cardiac lesions. It is of inestimable help in evaluating the preoperative state of the patient. It was used as a means of investigating the postoperative pulmonary complications, and the effect of spinal anesthesia upon the cardiovascular system. Further studies along these lines to permit us to arrive at more definite conclusions are being undertaken.

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BRIEF COMMUNICATIONS AND CASE REPORTS

STREPTOCOCCIC MENINGITIS AND SEPTICEMIA

RECOVERY AFTER TRANSFUSIONS FROM DONORS WHO HAD HAD SCARLET FEVER

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Case Report.—A married white woman, aged 28, was admitted to St. Margaret's Hospital September 15, 1935, because of bleeding from the uterus since an abortion induced two weeks previously. Temperature, 101.4° F. Pulse, 118. Respirations, 28. She was pale and weak. The uterus, palpated from the rectum, was about three times its normal size.

The morning following admission, her temperature was 99.2° F.; pulse, 112; respirations, 20. Hemoglobin, 40 per cent; erythrocytes, 2,290,000; leukocytes, 5,100; differential: polymorphonuclears, 48 per cent, 52 per cent lymphocytes. She was flowing profusely. Under spinal anesthesia, a mass of decidual tissue was removed, and the uterine cavity loosely packed with dry gauze. A transfusion of 600 cc. of citrated blood was given. That evening, her temperature rose to 104.6° F.; pulse, 126; respirations, 28.

For the ensuing seven days, her temperature varied between 101.8° to 105.0° F. She complained of severe headache, and of pain in the upper lumbar region. Blood culture September 18 showed a growth of *Streptococcus hemolyticus*. A transfusion was given daily for ten days, usually in the amount of 600 cc. The blood for eight transfusions was obtained from individuals who had had scarlet fever, although not recently; of six of these donors, two who stated that they had had the disease in severe form gave blood twice. It seemed to us that the therapeutic response was more marked when blood was transfused from the latter two donors.

Several herpetic vesicles appeared on the patient's lip September 20. Two days later, more developed in a patch 4 cm. in diameter near the umbilicus. Her headache became excruciating and her neck gradually became stiff. On September 23, opisthotonos was present. On that day, 50 cc. of cerebrospinal fluid was removed, which contained 7,250 cells per cc., almost all polymorphonuclear leukocytes. Culture of this fluid showed a growth of *Streptococcus hemolyticus*. Immediately after withdrawal of this fluid, the headache, backache, and rigidity of her neck were relieved. On the following day, her temperature dropped to normal, and at no time thereafter exceeded 100.0° F. No bacteria were obtained from a blood culture September 24.

The patient was kept in the hospital for 12 days after her fever subsided. She complained occasionally of headache in both parietal regions. She was allowed to get out of bed September 30, and returned to her home October 5. On October 18, she states that she still had an occasional headache and was easily fatigued, but was able to do her housework.

A discussion and bibliography of the use of scarlet fever serum (although all the cases of meningitis died), is given by: Thalhimer, W., and Levinson, S. O.: Pooled Convalescent Scarlet Fever Serum Treatment of Diverse Streptococcic Infections. *J.A.M.A.*, 105, 864-866, September 14, 1935.

STENOSIS OF GASTROJEJUNAL STOMA CAUSED BY
RETENTION OF MURPHY BUTTON*

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NEW YORK, N. Y.

CASE REPORT

A MALE, aged 46, was admitted to Beekman Street Hospital August 4, 1933, because of a sudden collapse associated with profuse hematemesis. He had had two episodes of vomiting blood during the previous 24 hours, the passage of tarry stools for one week, and a ten year history of digestive discomfort. He was in moderate shock, pulse of 110, blood pressure 90/60, red blood cell count 3,000,000, hemoglobin 50 per cent.

He was placed on a supportive regimen for a bleeding peptic ulcer and, except for another massive hemorrhage on the sixth day, when the red blood cell count fell to 1,600,000 and the hemoglobin to 30 per cent, his condition gradually improved enough to permit a roentgenologic examination September 11. This revealed a large penetrating ulcer 4 cm. in diameter on the lesser curvature of the stomach in the region of the reentrant angle. A second examination, four weeks later, showed no decrease in the size of the lesion, and a suspicion of malignancy was entertained. An attack of paroxysmal tachycardia lasting 36 hours delayed operation until October 24, 1933, when exploration revealed an indurated, suspiciously malignant, penetrating ulcer 2.5 cm. in diameter at the reentrant angle of the stomach. A Bilroth II type of gastric resection was done 5 cm. above the level of the ulcer lesion, employing a Murphy button to effect a posterior no-loop gastrojejunostomy. This was used because of the high resection necessitated, and the desire to complete the procedure as expeditiously as possible because of the patient's unfavorable condition. The lesion proved to be a benign gastric ulcer.

For ten days the postoperative course was uneventful. Then the patient began to regurgitate small amounts of food and to vomit. Daily lavages and frequent small feedings improved these symptoms, which were thought to have been due to gastric atony and distention. Repeated roentgenologic examinations showed the Murphy button to be still retained in the gastro-enteric stoma and it was still there when he was discharged October 27, 1933.

Three months later (January 25, 1934), the patient was readmitted because of persistent regurgitation of food, frequent vomiting, increasing weakness and a loss of 15 pounds. Roentgenologic examination revealed no change in the position of the Murphy button. The patient continued to vomit and rapidly lost ground despite all supportive measures. Exploration was performed February 12, 1934. The Murphy button was found to be still retained in the gastrojejunal stoma. After freeing the anastomosis from the transverse mesocolon, an incision was made over its anterior aspect exposing the button. The cause of the obstructive symptoms became apparent. The intervening tissue which ordinarily sloughs away, due to pressure necrosis when the button is closed, had persisted as a viable diaphragm. Removal of the button, and the establishment of an adequate stoma by the suture method, was followed by an uncomplicated convalescence.

In the 1933 Year Book of Surgery, Dr. Evarts A. Graham remarked: "It is interesting to read that the Murphy button is still being used. One cannot resist the temptation to ask, why?" The superiority of suture methods over any mechanical device as a means of effecting intestinal anastomoses warrants their unquestioned use whenever feasible. However, it is our feeling, in spite of the complication illustrated by the present case, that there are occasions when the employment of the Murphy button may not only be

* Presented before the New York Surgical Society, October 9, 1935.

preferable but actually be indicated. In high gastric resections where a minimum of stomach remains, a suture anastomosis is technically difficult, if not impossible. In such instances, Murphy button anastomosis may be effected with greater facility and safety. There are occasions, also, where an intestinal resection must be completed as expeditiously as possible because of the condition of the patient due to gangrenous strangulation in elderly or toxic individuals, multiple gunshot wounds of the gastro-intestinal tract, or a sudden unfavorable change of condition during the course of operative procedure. A Murphy button anastomosis may save much valuable time and be the factor determining a successful outcome. These indicated instances—and we believe the present case was one—occur frequently enough in any active gastro-intestinal or acute surgical clinic to convince us that the Murphy button still retains a place of usefulness and is not as yet to be relegated to the historic curiosities of the past.

DISCUSSION.—DR. JOHN D. MCCREERY (New York) stated that insofar as he himself had used it or had seen it used, the indications for the Murphy button have been rare. Its use has been due, in large part, to the influence of tradition. The time saved by its employment is not sufficient to make it preferable to suture anastomosis with the few extra moments the latter procedure requires, in view of the number of cases reported in which the button has been retained or stenosis has followed its use.

DR. RICHARD LEWISOHN (New York) had observed the rise and fall in the popularity of the Murphy button during a period of about 40 years. In the early part of this century the button was most popular and was used for all forms of gastro-enteric and entero-enteric anastomoses. During the last decade, however, most surgeons had discontinued its use. He agreed with Doctor Mage that the button has a very important place in gastric surgery and said he did not know how a very high subtotal gastrectomy could be performed without the button. Unless it is used in these high resections, it is necessary to make an antecolic anastomosis with entero-anastomosis which requires at least half an hour. With the aid of the button a safe anastomosis can be effected in a few minutes.

Undoubtedly the button may occasionally cause complications. Two very interesting cases had been reported by him 20 years ago under the title: "Stenosis of Stoma Simulating Recurrence of Carcinoma of the Stomach." In these cases recurrent symptoms (vomiting, loss of weight, *etc.*) occurred six months after the primary gastric resection. Reoperation showed that these symptoms were not due to a recurrent carcinoma. In one case the button had remained *in situ*, in the other the stoma had narrowed down to the size of a pencil.

RECURRENT PROLAPSE THROUGH THE STOMA OF A COLOSTOMY

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RECURRENT prolapse through the stoma of a colostomy is a trying complication. Loose mesocolic attachment and unsatisfactory parietal fixation

may be easily corrected surgically, but success is problematical where the colostomy fails because of infection, poor cooperation, age, thin atrophic abdominal wall, and gaping orifices in weak fascial structures. Such a case was encountered which entailed several surgical failures complicated with wound infection, and which was successfully treated by the following procedure.

CASE REPORT

A white male, aged 64, was admitted to the Jeanes Hospital on October 24, 1930. He was mentally disturbed, hypertensive and senile. He had a Kraske operation performed for a large rectal carcinoma, subsequently complicated by a saphenous phlebitis. On August 24, 1931, a large prolapsing colostomy mass was found. At operation, the fascia appeared widely separated. The intestine was returned to the abdomen and fascia and muscle layers carefully approximated. Recurrence was rapid and by September 15, 1933, the everted intestine occupied an abdominal quadrant. Five weeks after a third operation, another prolapse was discovered. These three failures, the thin atrophic fascial walls, danger of infection and the mental irresponsibility of the patient, led to the institution of the following procedure. The patient forcefully extruded as much intestine as possible. A finger was then inserted into the gut lumen to determine the presence of any additional loop of intestine within the extruding mass. A semisolid rubber tube, 2 cm. in diameter, was then introduced into the lumen beyond the abdominal wall, and fine rubber jute tubing wound tightly over mucosa about the base of the mass and clamped. Five days later, the non-viable material was removed by cautery, one day later the tube and ligature were removed without bleeding or infection. Healing followed rapidly, and thus far there has been no recurrence of the prolapse. Rather generalized cramping and shooting abdominal pains developing 24 hours after the ligation were not associated with hyperperistalsis, vomiting or other features of acute intestinal obstruction. For two preoperative days, and until the termination of the ligation, the patient was kept on a liquid diet. During the six day period, the colostomy tube was frequently flushed out with saline solution, alternating with liquid petrolatum.

This method of treating prolapse through the stoma of a colostomy depends on securing the maximum extrusion of intestine possible previous to ligation, while inclusion of an extra loop of intestine must be guarded against by careful preliminary examination.

We subsequently learned that Doctor Reid had reported the employment of this procedure in the treatment of irreducible prolapse of the rectum in the *American Journal of Surgery*, p. 359, May, 1933.

ILEOCECAL RESECTION FOR ACUTE DIVERTICULITIS OF SOLITARY DIVERTICULUM OF ASCENDING COLON*

DEWITT STETTEN, M.D.

NEW YORK, N. Y.

Case Report.—A woman, 35 years old, was admitted to Lenox Hill Hospital October 15, 1934. For two years she had complained of occasional sharp pains in the right lower quadrant with some abdominal distention. For some months previous to her admission she had had a vague feeling of discomfort in the abdomen, particularly

* Read before the New York Surgical Society, November 13, 1935.

in the right lower quadrant. She had been very constipated, and complained of distention, headache, vertigo, general malaise, nervousness and depression. On the day previous to admission she had an attack of abdominal cramps, accompanied by abdominal distention. She did not vomit, and her bowels moved several times, accompanied by large amounts of flatus as the result of catharsis, and was somewhat relieved. There was definite tenderness in the region of McBurney's point, and a finger-like sensitive mass was palpable in this region. There was no rigidity. Vaginal examination showed some tenderness in the right fornix. Temperature, 100.4°. Leukocytes, 18,000; poly-



FIG. 1.—Photograph of resected and opened ileocecal portion of intestine showing opening of diverticulum on inner side of gut above ileocecal valve.

morphonuclears, 85 per cent (immature 17 per cent); lymphocytes, 6 per cent; monocytes, 9 per cent. She was considered to be suffering from acute appendicitis.

Operation.—A right lower rectus incision was made and before opening the abdominal cavity, the mass that was previously palpated could be very distinctly felt through the peritoneum. There was a moderate amount of free clear serous fluid in the abdominal cavity. Lying below the cecum was a very long, large, coiled, but not acutely inflamed appendix. On the inner aspect of the ascending colon about three-fourths of an inch above the ileocecal valve was a hard, tumor-like mass, involving the gut and the adjacent mesentery; about the size of an egg. It was quite movable. Its feel and appearance suggested an inflammatory rather than a neoplastic growth. On palpating from the outside by invaginating the gut, a large, round, crater-like defect was noted on the inner wall of the gut which had all the characteristics of a punched-out ulceration. It was large enough to permit the entrance of the tip of the thumb. The edges were apparently smooth, not everted and not indurated. In the adjacent mesentery,

running almost down in the root, were a number of slightly enlarged, fairly firm lymph nodes, which also suggested inflammatory involvement rather than neoplastic metastases. There were no signs of any other metastases in the abdominal cavity. There was no evidence of diverticulosis in any other portion of the colon.

A diagnosis of a solitary, penetrating ulcer, probably benign, of the ascending colon, was made, and an ileocecal resection with a lateral isoperistaltic ileocolostomy between the ileum and the lower portion of the ascending colon was performed. Gross examination of the specimen confirmed the impression that the lesion was not malignant (Fig. 1). Microscopically it was shown to be an acutely inflamed false diverticulum of the ascending colon with acute peridiverticulitis and pericolicitis with acute lymphadenitis of the mesenteric lymph nodes, the diverticulum having worked its way between the leaves of the mesentery. Its cavity was lined with mucous membrane. The appendix showed chronic appendicitis and peri-appendicitis. There was no evidence of malignancy.

Postoperative Course.—For a week there was some distention, vomiting, hiccough and cramps, but with good pulse and very little temperature. After that her bowels began to move freely and her convalescence was quite uneventful. The abdominal wound healed by primary union with no trace of leakage from the intestinal suture line. She has been perfectly well since.

Diverticulitis in a solitary diverticulum in this region must be extremely rare, and naturally will invariably be confused with acute appendicitis. In a search of the literature no record of a solitary diverticulum in just this region has been found, but in a report by H. Thomsen,¹ on solitary diverticula of the cecum, he cites eight cases found by him in the literature, and presents three additional instances. The ages of the patients varied from 20 to 60. They appear singly or, at the most, as two or three small pouches, the size of a pea to that of a walnut, on the anterior wall of the cecum. The symptoms are identical with those of acute appendicitis, and the diagnosis in all cases has been acute appendicitis.

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TRANSACTIONS OF THE AMERICAN SURGICAL ASSOCIATION

MEETING HELD IN CHICAGO, ILL.

ADDRESS OF THE PRESIDENT THE MAKING OF A SURGEON

EUGENE H. POOL, M.D.

NEW YORK

THIS is my first opportunity to express appreciation of the great honor you have conferred upon me by electing me president of the American Surgical Association. Being unexpected, it is the more welcome.

Instead of attempting the customary philosophic discourse, I have chosen as the subject of my address, "The Making of a Surgeon." It is popularly believed that a surgeon, like a poet or musician, is born, not made; but in reality every detail of his development is the result of long continued effort and concentrated purpose. He is an artificial, not a natural product. But it must not be inferred that extrinsic influences are wholly responsible for his development. His progress for the most part is dependent upon self-training. During the period of preparation, organized medical education is mainly responsible, but it becomes progressively less important as the specialized field is entered and followed. In the preparatory period the function of organized education is clear cut: in the period of specialization it is confused and uncertain; so much so that there is perennial discussion as to what should constitute the training of a surgeon.

Let us view the problem from the standpoint of him who is being trained. Let us put ourselves in his position, and travel along the paths which he must tread. In order to secure a contemporaneous viewpoint, rather than one in retrospect, I stimulated our house officers to analyze the problem, and to record the queries which arose during their discussions. We can perhaps profit by the friendly cogitations of this composite young surgical mind.

It is usually while he is still in school that a boy elects medicine as his profession. His reasons vary widely. He thinks, perhaps, that he may thereby secure an established social position; or he hopes by it to achieve substantial material reward: or he is influenced by the fact that he possesses some mechanical adroitness. Perhaps his father says of him, "Charlie can do anything with his hands. He has done all our repairs since he was eight years old." But the most universally controlling motive is humanitarian; an indefinite hope of contributing to the welfare of mankind. It may originate in the memory and inspiration of the kindly old gentleman who drove out one stormy night to treat him for croup; a man who, he had observed—like Ian McLaren's Doctor MacLure—"did his best for the need of every man, woman and child in this straggling district, year in, year out, in the snow and in the heat, in the dark and in the light, without rest and without holiday for forty years. It was mighty tae see him come: the varra look o' him was victory." So the boy elects medicine, without carefully weighing the duration and intensity of the struggle, without due consideration of the financial strain.

He enters college actuated by an ideal. For two to three and a half years he must devote much of his time to premedical courses. He does not appreciate what a medical career involves and in many instances it is only after years of effort that he finds the life is not what he anticipated. Would it not be well for his college at the outset to inform him as to the true conditions? Should not a kindly soul explain to all premedical students the struggle, competition, expense and doubtful rewards; not with the view of discouraging a serious aspirant, but as a matter of justice, and to prevent disappointment and waste?

In his college course the young man should receive a broad training. A thorough knowledge of English, philosophy, mathematics, economics, and the languages will, in the long run, be of more value than a smattering of biology and zoology. Should not sculpture and the art of drawing and painting be more highly regarded, combining as they do, dexterity with an esthetic outlook? "Colleges," said Emerson, "can only highly serve us when they aim not to drill but to create: when they gather from far every ray of various genius to their hospitable halls and by the concentrated fires set the hearts of their youth on flame." The premedical requirements appear to me too ambitious and too highly specialized, and for this opinion I find support in the Report of the Commission on Medical Education,* which emphasizes the lack of proper motivation of the premedical science training in many colleges, and states that much of the science teaching is presented from the special interest of the teacher or department. Organic chemistry, the Commission finds, is frequently taught from the standpoint of industrial uses, and much of the teaching of inorganic chemistry emphasizes its commercial applications. An adequate knowledge of the principles and methods of these sciences for the purposes of medical education could probably be secured in less time than is now required "if the courses were focussed upon the needs of the student."

* "The Report of the Commission on Medical Education" has been fully drawn upon in this discussion.

The objective should be a broad general education. An intellectual attitude, common sense, the knowledge of people, of the humanities, of one's self, will be more useful than premature specialized training in preparing the student for a successful and helpful career. Specialized training should come more slowly, and by absorption and election. Science is a strong draught which often intoxicates the immature mind. Its study should not be prejudicial to cultural development and the appreciation of the beauties of life. The development of a surgeon must be of many years' duration, and the early years must of necessity be lean and unproductive. Therefore the plan of education should be laid for a long race.

"The heights by great men reached and kept
Were not attained by sudden flight,
But they, while their companions slept,
Were toiling upward in the night."

My views in this respect are at variance with those commonly accepted and followed. Note, for instance, the system in England. A boy often has completed his premedical courses on entering the university; there, he customarily devotes all of his time to the medical sciences. He thus may embark on clinical work on quitting the university at 21 or 22 years of age. This is an extreme form of the early specialization which I condemn.

"What medical school shall I enter?" the enthusiastic young Sir Galahad asks. "I am at last on my own, with the world at my feet." But how hopes are to be shattered! Some months after his application, months of fretting and uncertainty, a curt message tells him that he has not been accepted by the school of his choice. In the leading schools only one in ten is taken. He must try, and perhaps keep on trying elsewhere, until at last he is privileged to enter a school. Although I recognize the great difficulties confronting the authorities in making their selections I fear there is not always the kindness and judgment shown which should guide those who decide the destinies of young men. Every candidate should find a welcoming, not a repelling or suspicious atmosphere.

It is generally believed that "the type of student who studies medicine is determined by the professional opportunities and social recognition of the physician." While this is to some extent true, in the last analysis it is the instructors in the premedical courses of our colleges who select the future doctors of the country, because the medical colleges rely largely upon their recommendations in selecting candidates. It is a question whether these men recognize this responsibility and give sufficient thought to the qualifications of candidates beyond the question of marks. They should be instructed as to the importance of their influence and be made more cooperative. Where a medical school is associated with a university it would be advisable for its science instructors to participate in the premedical science courses in the college. This would not only be an inspiration to the young man but would also aid in the selection of the proper candidates.

The undergraduate surgical courses are pretty well standardized, and the

same principles and policies prevail in most schools. A perusal of the remarkably comprehensive report of the Commission on Medical Education, published in 1932, shows what immense efforts are being made towards perfecting the undergraduate courses in our medical schools. It is well recognized that the fundamental purpose of medical education is to provide enough competent men to meet the needs of the community for the care of the sick and the prevention and control of disease; and that the method should be to teach the man to think for himself, not, as of old, to cram his mind full of facts. There seems little of importance to criticize, although we still hear discussions as to details. It is often stated that anatomy has become slighted, yet it must be recognized that the weight of the curriculum as a result of the many added courses now makes it impossible to train all students, as of old, in the details of anatomy. Therefore, the surgical aspirant must supplement the routine courses by advanced anatomic studies, which should include the application of anatomy to surgery. The same may be said of physiology which, I think, is equally important. Pathology is perhaps being unwisely curtailed. Undue weight is placed on rare diseases, because they interest the instructor. It is more important to teach the differentiation of carcinoma of the rectum from hemorrhoids than to put the young man ever on the alert to recognize a sacrococcygeal chordoma. There does not appear to be sufficient coordination among the various departments in their teaching. Moreover, the pendulum has swung too far away from didactic teaching, and the lecture has received too severe an indictment. Personal contacts with mature experienced clinicians are neglected, and the young man of relative inexperience is given too prominent a place as a teacher. Experience, mellowness, stability from years of struggle and strife are not sufficiently appreciated and used. It were better for the student in his early years to be a hero worshiper than an iconoclast.

The medical degree is at last his, but this, he realizes, is only the beginning. He faces the problem of obtaining an internship, to learn the practical uses of his theoretical knowledge. It is fortunate that about 95 per cent of graduates obtain this opportunity. Graduate study then begins. In the case of surgery it seems obvious, though not generally accepted, that at some part of his training he should become thoroughly familiar with the human body and its general deviations from normal. This demands an intimate knowledge of internal medicine, psychiatry and pathology. At least one year on a medical service should be elected at the outset, special attention being directed to the heart and lungs. If delayed, it will never be done. The man thus gains a first hand working knowledge of the unit on which he is to do his life work. I maintain that successful surgery depends largely upon anticipating and avoiding troubles, and recognizing and treating complications in their incipency. The surgeon, then, must be expert with the stethoscope and with general changes in the condition of a patient. He must have the mind and eye of an internist, the hand of a surgeon. The interests of the patient are best conserved if all cases are followed and treated by the internist and surgeon together. But this is possible only in institutional and group

medicine. Therefore, the surgeon should be so equipped medically that he can recognize at the first signs that something is wrong, and pretty much what is wrong.

Quite as important as familiarity with the physical aspects of man is some knowledge of his mental habits and peculiarities. The psychology of the patient, that is his susceptibility and responses to outside influences and personalities is not a new concept. About 1800 years ago Galen exhorted his pupils to be careful not to arouse and irritate the patient when entering the sickroom by stumbling and screaming. He gave them benevolent advice with respect to their clothing, their behavior and the conversation to be held with the patient. Cleanliness was recommended, and they were forbidden to eat onions or garlic or to drink too much wine before visiting the sick.

While every surgeon recognizes that his actions and words often have a profound influence on the patient, this is not sufficient. He should be familiar with the peculiarities of the mind which are classified under such terms as neurosis, psychosis and hysteria. We are all more or less unconsciously psychiatrists, but there should be a deliberate and planned effort to make the young man a good psychiatrist, and for this he should have formal training. A more general adoption of this principle would probably minimize the activities of the cults.

In 1927, rumors were heard that some of our surgical cases had landed in Bloomingdale Asylum; also that criticisms were expressed that operations had been performed upon these patients. This led us to arrange for a close association with Doctor Henry,* one of their leading psychiatrists. His findings, based on 300 psychiatric consultations, may be summarized. Fifteen per cent of the patients in general hospitals require psychiatric supervision. While you may think such a high percentage does not apply elsewhere than in New York, nevertheless the problem is a real one in every community. The study revealed the absence of psychiatric data in the histories, an unscientific attitude toward the psychiatric features in the patient's illness, and a laborious method of arriving at a diagnosis through a process of elimination. An average of seven days elapsed after admission to the hospital before there was a psychiatric consultation even in cases found to be uncomplicated by physical disease. A period of a week to a month passed before the patients were discharged. There seems to be a general misconception that in order to deal with psychiatric problems the physician must ever be on the watch for obscure psychic influences and lecherous fixations. This is without foundation.

Doctor Henry recommended that no medical student should be permitted to graduate without having had an elementary course in the psychopathic aspects of general hospital practice; and that a period of study in a psychopathic hospital should be a part of all hospital internships. With these recommendations I emphatically agree.

During his internship, as well as during his undergraduate days, the

* Some Aspects of Psychiatry in General Hospital Practice: G. W. Henry, Bloomingdale Hospital.

young man should be encouraged and directed in the use of the library, which should be complete and easy of access. The urge comes chiefly from example. We have all felt the stimulation of seeing Paget's works presented at a clinic. Another teacher brings from the library Duplay's original article to reveal the details of the lesion which is known by his name. While such examples could be multiplied, this practice is far too infrequent.

We might profit by Ruskin's observation, "That to use books rightly is to go to them for help, to appeal to them when our knowledge and power of thought fails: to be led by them into wider sight—purer conception—than our own, and receive from them the united sentence of the judges and councils of all time against our solitary and unstable opinion."

The problem as to an internship centers upon the type of service. In the average hospital the internship affords an admirable training in the fundamentals of surgery, though it does not make a surgeon; under the resident system the resident obtains a supertraining, the intern as a rule relatively little; indeed, it is said that the resident often makes the life of the intern one of misery. It is pretty well established that there is a place for both systems. However, the actual details as to their best practical application appear nowhere to have been perfected. The intern plan is traditional and has been in vogue since the earliest days of American hospitals. Radical changes seem indicated; to these we shall refer later.

With the resident system is closely linked the full time policy which in practice has offered certain advantages; notably, more supervision, teaching and research. But, whereas devised to correct an evil, it has in some instances become an evil.

Many surgical departments are now so large and many sided that there must be a full time director. But should the great contributor or research worker, who is as rare as the great composer, be obliged to spend his time on administration work? No! He should be carefully nurtured like a rare plant. It is as appropriate to put him in charge of the details of laboratories, museums, elementary teaching and questions of discipline, as to put a Wagner in charge of music in a girls' seminary.

While the administrative head of the surgical department in the larger institutions must devote his whole time to the service, it is problematic how far the full time principle should be extended beyond this. The question obviously has not been satisfactorily answered, since we see in every progressive institution frequent changes in its methods. My own conviction is that certain of the younger men should be on full time—Fellows, if you please—also the younger attendings, who might be allowed to practice in the institution. The upper group should be on part time. I believe that men who have struggled in the competition of practice, and have survived, are in general better qualified to tell the young man who is embarking on practice what are the problems, and how they should be met, than is the sequestered hermit who has never been out of a hospital or off a salary.

The discussion of the system, however, appears to be receiving more

attention than it deserves. The interests of the institution, whether it be hospital or school, depend upon the cooperation and confidence of the public and the outside profession. A broad minded generous policy under almost any method, equal professional ability being assumed, will spell success in teaching, care of the patient and clientele for the institution. A short sighted selfish policy will beget disloyalty, lack of confidence and failure. The results, therefore, depend more upon the individual than the method.

The intern should be taught to recognize that every surgeon should be impregnated with the tenets of pathology. Surgery and pathology have been closely linked from the beginning. As you must recall, Bichat, the father of modern histologic pathology, would probably have died unsung had it not been for his contact with Pierre Desault and the inspiration he received from that master surgeon. In recent developments surgery has been advanced quite as much by the microscope as by the knife.

I feel that the laboratories of a hospital should be the hub, intellectually and physically, from which all else radiates; and, reciprocally, that all paths should be planned to lead to them, so that in the course of his daily perambulations the clinician perforce finds himself in juxtaposition with the laboratories; that the laboratories be directed by a broad minded leader who will welcome the clinician and give willingly of his time. In a word, the laboratory should be the vitalizing force of the institution. Philosophy, erudition, research, encouragement, should there be found. The clinician without this stimulus will in general have a narrow limited viewpoint. On the other hand, such daily contacts will lead him from the narrow confines of pure clinicism (if I may coin a word) into the limitless expanses of scientific and philosophic thought. Intimate contacts should be encouraged; these are possible only by rubbing heads over the same eyepiece. If this attitude does not prevail, there is a tendency to become more and more of a technician and rule of thumb clinician with a narrowing in breadth and lowering of ideals.

Our young man—though now some 30 years of age—is at last faced with the problem of shifting for himself. What does he find? The field of medicine is overcrowded, if we may accept such an authority as the Commission on Medical Education. There is every reason to believe that the specialty of surgery is particularly overcrowded. It affords unusual attractions through its spectacular aspects, its rapid and clear cut results, its greater financial rewards.

The oversupply of physicians in this country, estimated at 25,000, is most marked in densely settled areas. There should be greater efforts to influence a larger number of recent graduates to enter the rural districts. They should be informed as to the needs and opportunities and even trained for such work as has been done in some of the smaller schools, as was strikingly presented to this Association by Elting of Albany.

The vast extension of knowledge and technical developments in recent years makes it impossible for any man to be experienced in all branches. Specialization has therefore become necessary, but it has been overdone, as

was emphasized by our former President, Doctor Jones. Twenty years ago the general surgeon performed tonsil and mastoid operations as well as gynecologic, urologic, neurologic and orthopedic surgery. It became evident that the welfare of the patient was not met by such widespread activities. Gradually the field has been subdivided, until now we have the hand, plastic, hernia, breast, rectal and thyroid specialist, and we may expect, if the tendency is not arrested, a further extension of specialism into even more minute subdivisions. Such extreme limitation is stultifying and unnecessary. Under these conditions the surgeon becomes almost exclusively a craftsman. Such a man cannot be a real teacher or director.

Some specialization is essential with the proviso that the specialist has had a preliminary general surgical training. We have all been called upon to remove a jugular vein after a mastoid operation and to do a jejunostomy after a hysterectomy, the specialist not trusting himself beyond his limited field; and how often are we called upon to correct the mistakes of the casual operator?

Our composite young mind, which suggested many of my topics, framed the question, "What place does research or experimental surgery occupy in the surgeon's training?" The answer calls for a subdivision of surgery; first, the purely clinical, which includes the casual operator, and second, those who are inherently investigative; the ones who will become notable teachers, trail-blazers and leaders. For the former, rule of thumb methods, obtained from the text-book, are satisfying; for the latter, everything seems imperfect; in them there is an ever present urge for improvement. The impulse is irresistible, and, as in philosophy, is the search for truth, not self-exploitation. Thus it depends upon the man. He who does research for self-exploitation had better leave it alone. He who does research from an impelling and irresistible impulse will profit greatly as a result of justifiable efforts.

I do not subscribe to the prevailing attitude in regard to research, that he who abuses a dog is necessarily a scientist and research worker, but he who performs worthily upon man is something to be despised; or that the laboratory is necessarily superior to the operating room as a means of learning to care for human ills and adding to our knowledge of man and his defects. No! Basic contributions are frequent through clinical observation and study, and often constitute research of a high grade.

"Know then thyself, presume not God to scan:
The proper study of mankind is Man."

Conditions of investigation or research now differ radically from the earlier days of medical progress. In the past, individuals pursued lines of investigation relatively unaided. Now, the important problems demand group effort. Take, for instance, the question of neoplasms. Vast progress certainly has been made during the fourscore years since modern pathology was initiated by Virchow's contribution on cellular pathology. The cell is still the unit or yardstick, but it is not its physical qualities alone which are now

satisfying: its life and habits, its physiology are calling for study. The biology of the cell under normal and pathologic conditions may be accepted as *the* most important scientific problem of today. Many phases of specialized knowledge are necessary to pursue this study, including pathology, chemistry, hematology, physiology and biophysics. This implies cooperative effort. But it may well be expected that as masses of facts are accumulated, another Darwin, with speculative attributes and a judicial mind, will link them into a coordinated web to explain the lawless cell development in the phenomenon known as cancer.

Although it is not primarily a question for the educator, there is one of vital importance to the young man—how to meet the financial burden of the nine or ten years from school through his internship; years when the self-respecting man wants to be self-supporting and in most instances must be self-supporting. At the age of 27 he finds himself theoretically qualified to earn a living in surgery. In reality he cannot expect an appreciable income from private patients much before the age of 40. He wants to know how he can live during this period—which, however, must be a period of preparation, not of waiting. During it, nice judgment is essential to make the minutes count. During this period, character, breadth of mind, knowledge of life are more important than at any other time, and are dependent largely upon his early training which we have recommended should be broadly planned for these attributes. This financial obstacle naturally limits the field materially, and it is found that more and more promising candidates drop out, either from necessity or lack of staying powers. Salaried jobs, governmental positions, private practice, personal indulgences, even an independent personal income, deflect them from the single minded pursuit of a surgical career, which means constant sacrifice, incessant work, and intelligent selection of the lines of effort.

As a matter of history, and years of observation, it is evident that the man *can* find some means of existing, for it was merely that to most of us during these lean years. No single method can be devised to meet all cases, nor can a categorical answer be given to the inquiring and disquieted young man. But he may be assured that his labors and patience will ultimately be rewarded by at least a living wage, and deep satisfaction in the attainment of some success in the career of his choice. Unfortunately, opportunities as private assistants, which formerly kept one going, are now rare, but many full time positions are available in the schools. The privilege of occupying such a position is of inestimable value; the responsibility is great upon him who makes these appointments. Fellowships should be encouraged, and efforts should be directed towards obtaining endowments for this purpose rather than for elaborate buildings and equipment.

Conditions are so rapidly changing in all phases of life that future developments are impossible to foresee. The relation of the profession to the public, as it affects medical practice, is fraught with uncertainty. Industrial and compensation surgery and group medicine are among the factors which are already affecting practice. But the situation in regard to surgery is

fairly clear. That pecuniary returns from private practice will diminish progressively seems certain; the public cannot and will not pay the fancy figures of the past. Moreover, the profession itself is beginning to frown upon the debasement of its reputation and dignity by profiteering. Consequently, commercialism, while not wiped out, will be far less of a temptation than in the past. Idealism and altruism will become more and more the dominating incentives. The high salaries which are paid in some schools to full time clinical workers are sure to be brought more to the plane of the salaries paid to similar grades in the nonclinical departments. The universities are feeling the pinch of the times and this will be one of the first means of curtailing expenses. Further, the 67 four-year schools are now quite adequately supplied with highly trained and competent men in charge of their surgical departments; therefore, there is not the same need as at the early part of the century for training a considerable number of men for academic lives. While each university must develop some younger teachers, only a very few of these will have opportunities for academic careers. The schools must, however, turn out a considerable number of capable surgeons to meet the needs of the community.

Certainly the weakest link in the chain of medical education is in postgraduate surgery. It is well nigh impossible under present conditions to provide operative instruction. A man cannot perform passably or safely as an operator without considerable experience. Theoretical postgraduate courses which include viewing operations or even assisting at operations give a man a dangerous self-confidence and false sense of security. We must face the fact that these men have the right to do surgery and are determined to do it. We must, therefore, accept the obligation of making them safe; in other words, training must be provided. The great teaching institutions are inadequate for this purpose. There are, however, vast facilities in the numerous nonacademic hospitals throughout the country. These should be organized and used for the purpose. The present form of internship is wasteful and should be modified so that the material is shared between interns and other graduate students. The latter should be signed up for a relatively long period and be allowed to operate under instruction and supervision, emphasis being placed as much upon principles as upon technic. The result of their efforts should weigh in the decision as to their qualifications as surgeons.

As urged by our last president, efforts should be more active to control the character of surgery and to protect the public from the incompetent and casual operator. Of course, this applies chiefly in the urban and other thickly populated districts, for in certain rural districts the general practitioner *must* do everything. The license to practice medicine should not include the privilege of doing surgery. In medicine, most conditions being self-limited, a poor practitioner is rarely a serious menace; but give him a scalpel with the patient under an anesthetic and he is dangerous beyond measure.

A man before embarking on surgery should have something more than a medical degree. A certification or registration based upon training, character and ability should be required. The qualifying and examining of a

candidate should be the function of the profession. When the profession has established a standard, its enforcement might well be in the province of the State. We may feel encouraged by the fact that progress in this direction has already been made. An American Board of Surgery is planned to carry out these principles. It should do much to correct this evil and should therefore receive our unqualified support.

The young men for three to five years after their internship might well act as apprentices. This would cut in on the work of the intern staff and attendings, but would do much if adopted by a large number of independent hospitals to meet the minimum requirements to practice surgery. In other words, three years devoted to assisting, operating under supervision, diagnosis, anteoperative and postoperative training should be required to obtain a surgical certificate. Only with such a certificate should a man be qualified to perform major surgery. Our system is antiquated and has not met modern developments. Other countries, led by Denmark, have adopted regulations for recognition as a specialist. They have recognized the indications and have met them by appropriate laws, which it would be well for us to study.

The history of surgery, as we know it, did not exist until the knowledge of bacterial influences and the development of anesthesia quickly changed a limited mechanical field into a vast science. Thereafter, for many years operative technic and the evolution of new and simpler operations constituted the teaching of surgery.

With the relative standardization of technic and of routine operative procedures, this phase is quickly picked up or taught. Diagnosis, judgment and postoperative management cannot be taught, they must be acquired. Original work must be inspired. But example and encouragement must be alive and ever alert to recognize and nurture the rare youth with the essential qualities. Teaching surgery is really a misnomer. Although the surgeon is made and not begotten, and the making in the advanced stages is dependent upon himself, is subjective rather than objective—yet opportunity, help and encouragement are factors which count.

As this is not a lecture to the young man nor a sermon to my peers, I shall not dwell upon the personal attributes such as character, industry, kindness and tact, which contribute so much to the individual's success. We may accept as the impelling motive the thought phrased by Phillips Brooks, "No man has come to true greatness who has not felt in some degree that his life belongs to his race and that what God gives him he gives him for mankind."

Membership in societies such as this should be, as it is, the reward and recognition of worthy work, appreciable accomplishments, honesty of purpose, and unswerving efforts to uphold the best traditions of the profession.

Anticipation of the forthcoming elaboration of my theme calls to my mind the words of Milton, "I shall detain you no longer, but straight conduct ye to a hillside, where I will point ye out the right path of a virtuous noble education; laborious indeed at the first ascent, but else so smooth, so green, so full of goodly prospect and melodious sounds on every side that the harp of Orpheus was not more charming."

STUDIES IN BRAIN INJURY INCREASED CEREBROSPINAL FLUID PRESSURE FROM BLOOD IN THE CEREBROSPINAL FLUID

AN EXPERIMENTAL STUDY

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EXACT knowledge is lacking of the anatomic and physiologic effects of head injury. Experimental study of the problem has been inadequate. Surgeons have carried over into the clinical field of cerebral trauma conclusions reached in physiologic experiments upon the normal animal, with little or no acknowledgment of the fact that the accepted phenomena might not occur in a damaged brain. These propositions were formulated and discussed in a recent review of the literature.¹

The present studies were undertaken in an attempt to fill in some of the blank spaces of the problem. They have resulted in new data on the relationship of blood in the cerebrospinal fluid to the pressure of the cerebrospinal fluid.

It has been recognized that blood in the cerebrospinal fluid exerts a deleterious influence. Bagley² demonstrated neurologic manifestations in dogs after the introduction of blood into the subarachnoid space. An inflammatory reaction in the meninges surrounding the red cells was seen. Essick³ observed "sterile meningitis" following injection of laked red cells. Bagley² recorded dilatation of the ventricle following the introduction of blood, and Wortis and McCulloch⁴ and Bagley² have shown late fibrosis in the meninges. Many clinical observers⁵ believe that blood in the cerebrospinal fluid is harmful. The inflammation caused by the red cells is presumed to hinder the escape of cerebrospinal fluid and hence to raise cerebrospinal fluid pressure.

In 1928 Howe⁶ suggested that the blood proteins in a bloody cerebrospinal fluid might be responsible for increased cerebrospinal fluid pressure through osmotic effect. He states: "A similar condition" (*i.e.*, an increase of cerebrospinal fluid through increased osmotic pressure from increased protein content) "occurs if the osmotic pressure of the cerebrospinal fluid is raised by a haemorrhage in the subarachnoid space or when an injection of serum is made into the subarachnoid space." Weed,⁷ in 1935 observed that the absorption of cerebrospinal fluid under a constant pressure is retarded by the presence of protein in the fluid. This phenomenon occurred with gelatin or the serum of the animal under experimentation.

METHODS.—Two types of experiments were undertaken. The first consisted of the study of cerebrospinal fluid pressure and anatomic changes following a standard laceration of the brain. On account of a definite association between the pressure curves and the amount of subarachnoid bleeding

observed in these experiments, an attempt was made to separate a rise in pressure due to the increased volume of blood in the cerebrospinal fluid from a rise due to some other mechanism. The general principle therefore of the second type of experiment was the replacement of measured quantities of cerebrospinal fluid by equal quantities of blood and its separate constituents.

Laboratory dogs were employed without choice of breed or sex. In general, large animals were used, the smallest weighing 9.8 Kg. A total of 121 dogs was employed. Food and water were withheld from the animals during the night preceding experimentation.

The anesthetic used in the first group of experiments was intratracheal ether, and in the second intraperitoneal sodium ethyl barbiturate (sodium amytal). The initial dosage of the latter was 50 mg. per Kg. body weight supplemented by additional doses of 5 mg. per Kg. when indicated by beginning restlessness. Control observations indicated that this anesthesia did not affect cerebrospinal fluid pressure, confirming the experience of Milles and Hurwitz.⁸

Physiologic Observations.—Cerebrospinal fluid pressure was observed by means of a straight manometer of 1 Mm. bore, which was filled with physiologic saline. A No. 17 lumbar puncture needle was introduced into the cisterna magna under aseptic precautions. This was connected with the manometer by a glass adapter and about 12 cm. of rubber tubing. During connection of the needle with the manometer, one to two drops of cerebrospinal fluid were lost in avoiding the entrapment of air in the system. Observations of the cerebrospinal fluid pressure at minute intervals were then made for a sufficiently long period to be sure that the pressure was constant within a range of about 15 Mm. This control period was never shorter than 15 minutes in the first group of experiments and 30 minutes in the second group. During the prolonged period of observation after the completion of the experimental procedures, manometer readings were continued at one minute intervals for three hours and at five minute intervals thereafter. The femoral artery was cannulated and a continuous kymographic record obtained of the arterial blood pressure throughout the experiments. The rectal temperature of each animal was recorded at intervals and the normal level of body temperature was maintained with electric pads.

Standard Laceration.—After the control period, a trephine opening was made over the parietal region and a button of bone was removed without injury to the dura. A fitted glass window⁹ was immediately screwed into the defect and time was given for the cerebrospinal fluid pressure again to become stable. The window was removed and a sharpened, bent wire was introduced through the dura into the cortex in an area free from cortical vessels and rotated within the substance of the brain from three to five times through 360 degrees. The same wire was used in all experiments, so that the lacerations produced were as nearly uniform as possible. There was no appreciable loss of cerebrospinal fluid during the introduction of the wire. Immediately on withdrawal of the wire the window was screwed back in place, so that the loss of fluid rarely exceeded one drop. Following the laceration the animals were kept under observation for from one to four hours.

Replacement Experiments.—Following the control period, a bulldog clamp was applied to the rubber tubing of the manometer connection about 1 cm. distal to the adapter. A hypodermic needle was introduced into the lumen of the tubing, and 2.0 cc. of cerebrospinal fluid were withdrawn. A second hypodermic needle was then introduced, and 1.5 cc. of the substance to be studied were injected. In order to wash out the system, this was immediately followed by the reintroduction of 0.5 cc. of the cerebrospinal fluid previously withdrawn. In the experiments in which 3.0 cc. of serum were

injected, 3.5 cc. of cerebrospinal fluid were first withdrawn and again 0.5 cc. reintroduced as the final step. In all instances both withdrawal and injection were done at the measured rate of 0.5 cc. per minute. This transient diminution of cerebrospinal fluid volume, with both withdrawal and replacement effected at a slow rate, did not materially affect the cerebrospinal fluid pressure (Chart 5). Pressure readings were begun by removal of the bulldog clamp immediately after completion of the injections.

Control Observations.—(1) Observation of the physiologic set-up without withdrawal or introduction of fluid.

(2) Withdrawal of 1.5 cc. of cerebrospinal fluid and immediate reintroduction of the same fluid.

(3) Withdrawal of 2.0 cc. of cerebrospinal fluid and introduction of 1.5 cc. of physiologic saline solution followed by 0.5 cc. of the cerebrospinal fluid withdrawn.

Experimental Substances Employed.—The appended modifications of blood were used to replace cerebrospinal fluid. In each instance, blood or its fraction was obtained from the dog under observation:

(1) Blood defibrinated by agitation with glass beads.

(2) A suspension of washed red cells. Whole blood was defibrinated and centrifuged. The red cells were washed three times and suspended in physiologic saline, made up to a volume equal to that of the blood treated. Hemolysis was minimal.

(3) A preparation of hemolyzed red cells. After separation of the red cells from defibrinated whole blood, distilled water was added to the former in volume equal to that of the original blood. If laking was not complete, ether was added and later evaporated until the original volume again resulted. 1.5 cc. of this solution, representing the hemoglobin and red cell stroma of 1.5 cc. of blood, were injected. No attempt was made to render the mixture isotonic.

(4) Blood serum. The blood was defibrinated and centrifuged for 15 minutes. A slight degree of hemolysis was present.

All the above materials were prepared and the injections were completed under aseptic precautions.

The animals were kept under observation for a period of from three to six hours. In one instance, observation was carried on for ten hours. Several attempts were made to obtain pressures on succeeding days, which for reasons to be detailed are not being reported.

Pathologic Observations.—At the close of the experiment, the carotids were injected with 10 per cent formalin and the brain was then removed with the dura intact except for the basal portion. After hardening, gross examination of the surfaces and cut sections for obvious lesions was made, followed in the experiments of the second group by microscopic examination of multiple sections through the brain substance and the meninges.

Discarded Observations.—All animals with abnormal body temperature were rejected.

On account of accompanying variability in the cerebrospinal fluid pressure, all animals were discarded in which it was difficult to maintain a steady level of anesthesia.

The occurrence of a bloody cerebrospinal fluid following puncture or of poor respiratory oscillations in the manometer tube, or of the necessity for a second puncture due to dislodgment of the cisternal needle necessitated the abandonment of many experiments.

Experiments in which the arterial blood pressure curves showed greater fluctuations than about 12 Mm. above or below the original levels are not

reported, except in an occasional instance when a greater blood pressure change appeared as a terminal phenomenon after hours of observation.

EXPERIMENTAL RESULTS.—*Standard Lacerations.*—The anatomic lesions created are not uniform. They can be classified in two ways, namely, by

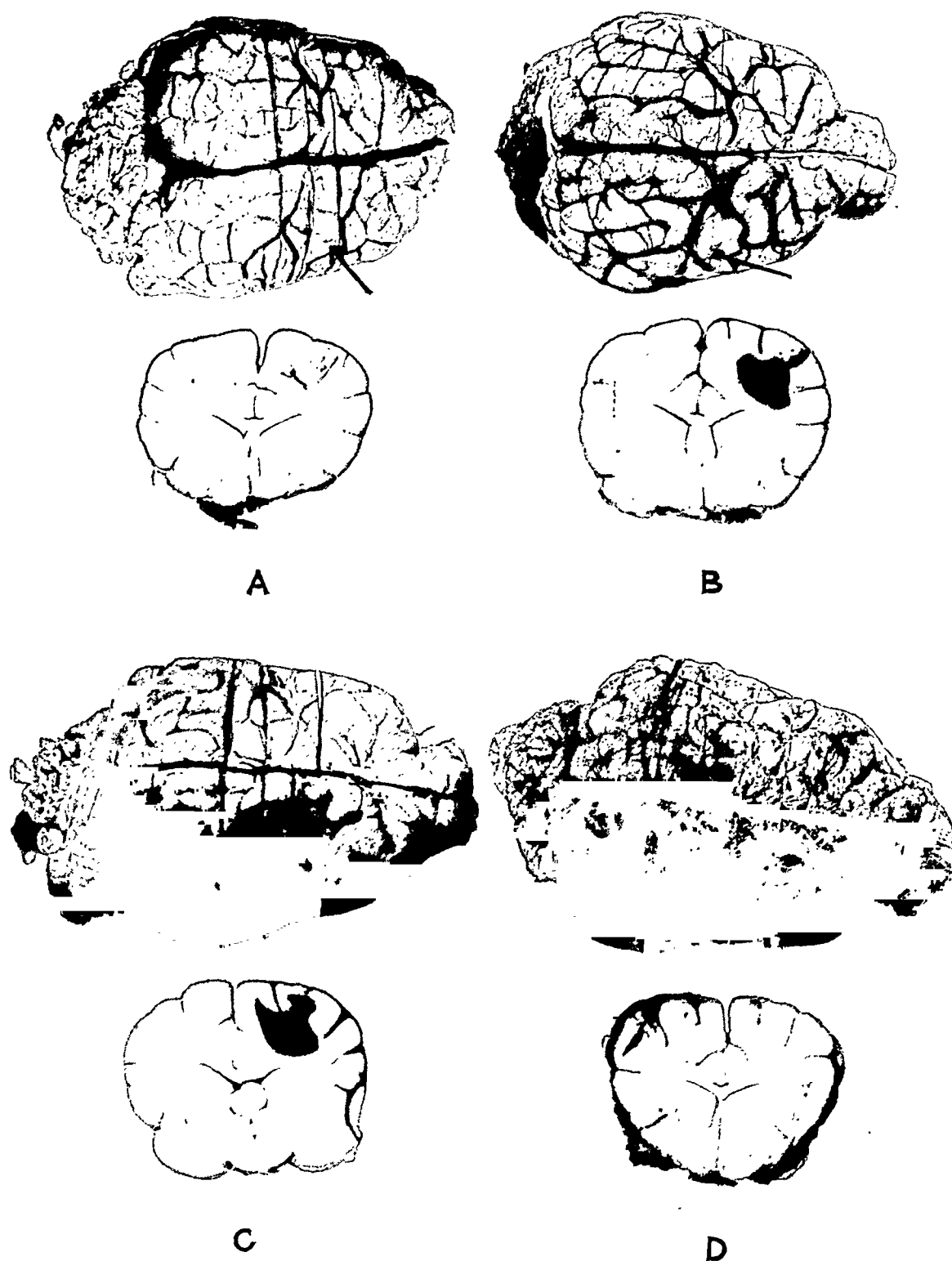


FIG. 1.—Laceration experiments. Subarachnoid bleeding: (A) Grade I. No gross bleeding. Arrow indicates point of entrance of lacerating instrument. Note minimal intracerebral clot. (B) Grade I. Arrow indicates point of entrance of lacerating instrument. Note large intracerebral clot. (C) Grade II. Moderate bleeding. Cross section indicates that the dark area of bleeding in the superior view of the brain is a relatively thin layer of clot. (D) Grade III. Massive bleeding. The superior view of the brain shows wider extent of hemorrhage, and the cross section shows enormously greater thickness of the clot than those shown in Fig. 1C.

the amount of intracerebral clot or by the amount of bleeding into the subarachnoid space.

Comparison between the cerebrospinal fluid pressure curves and the amount of intracerebral bleeding shows no correlation. For instance, there is obviously a considerable increase in volume of the brain shown in Figure 1B as compared with that shown in Figure 1A, and yet the pressure curves (Chart 1) both remain at the control level.

On the other hand, there is a direct correlation between the cerebrospinal fluid pressure and the amount of bleeding into the subarachnoid space. A classification based on the degree of subarachnoid bleeding may therefore be made. No gross bleeding into the subarachnoid space has been classified as Grade I; moderate bleeding as Grade II, and marked bleeding as Grade III.

In Grade I (Figs. 1A and 1B) the cerebrospinal fluid pressure does not vary materially from the original reading (Chart 1).

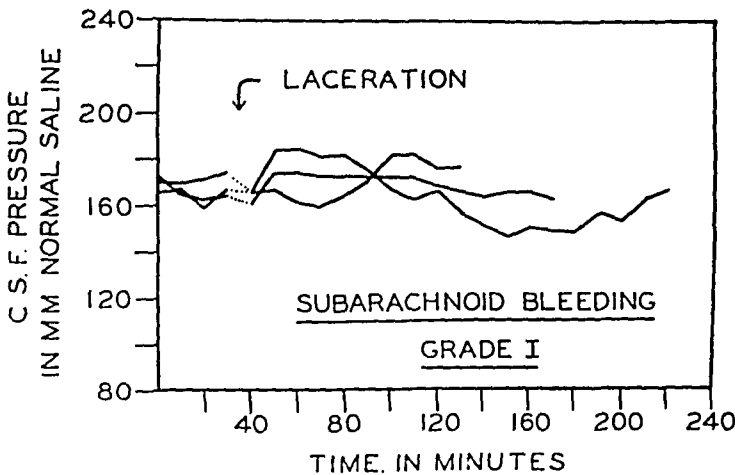


CHART 1.—Laceration experiment. No gross subarachnoid bleeding. The arrow in this chart and in Charts 2 and 3 indicates the time at which the laceration was effected. Note the absence of immediate disturbance of cerebrospinal fluid pressure from the experimental manipulations and the absence of any consistent rise in spite of extensive brain laceration.

In Grade II (Fig. 1C), there is an immediate moderate rise of cerebrospinal fluid pressure, occurring during the first 20 minutes, followed by a sustained elevation slightly lower than the maximum pressure (Chart 2). It will be noted that in one of these experiments the cerebrospinal fluid pressure curve does not rise. No explanation for this atypical observation can be presented.

In Grade III (Fig. 1D), there is an immediate rise of cerebrospinal fluid pressure of enormous extent, occurring in the first five minutes (Chart 3). This high peak is followed by a less abrupt fall, the pressure reaching within two hours a fairly constant level, elevated above the original pressure.

Replacement Experiments.—Control experiments, consisting of (1) prolonged anesthesia in the intact animal, (2) withdrawal and reinjection of cerebrospinal fluid, and (3) replacement of cerebrospinal fluid by physiologic salt solution, demonstrate no significant change in cerebrospinal fluid pressure (Charts 4 and 5).

BRAIN INJURY

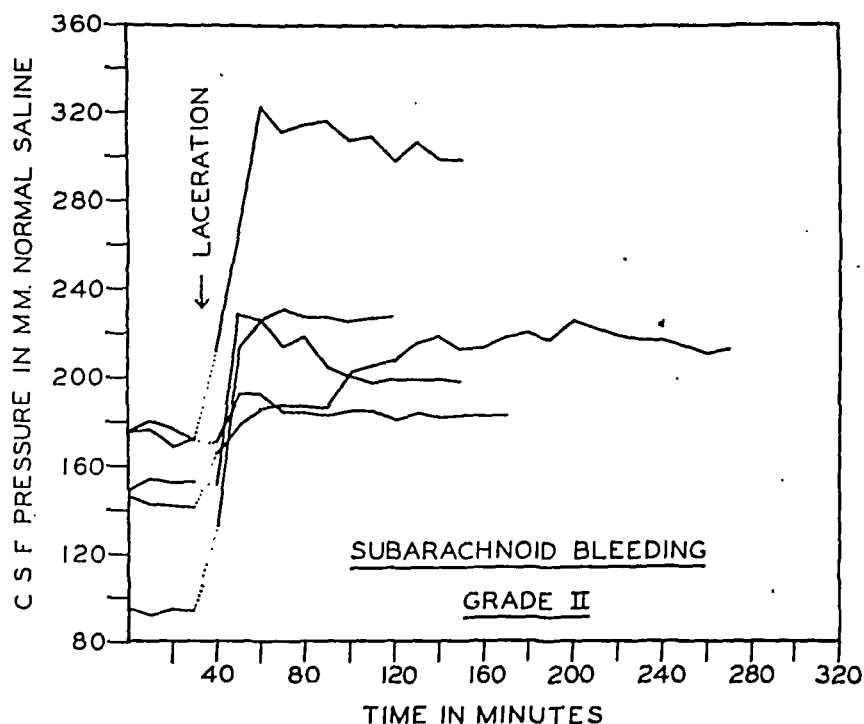


CHART 2.—Laceration experiment. Moderate subarachnoid bleeding. Note immediate rise of cerebrospinal fluid pressure with slight tendency to later fall in most experiments.

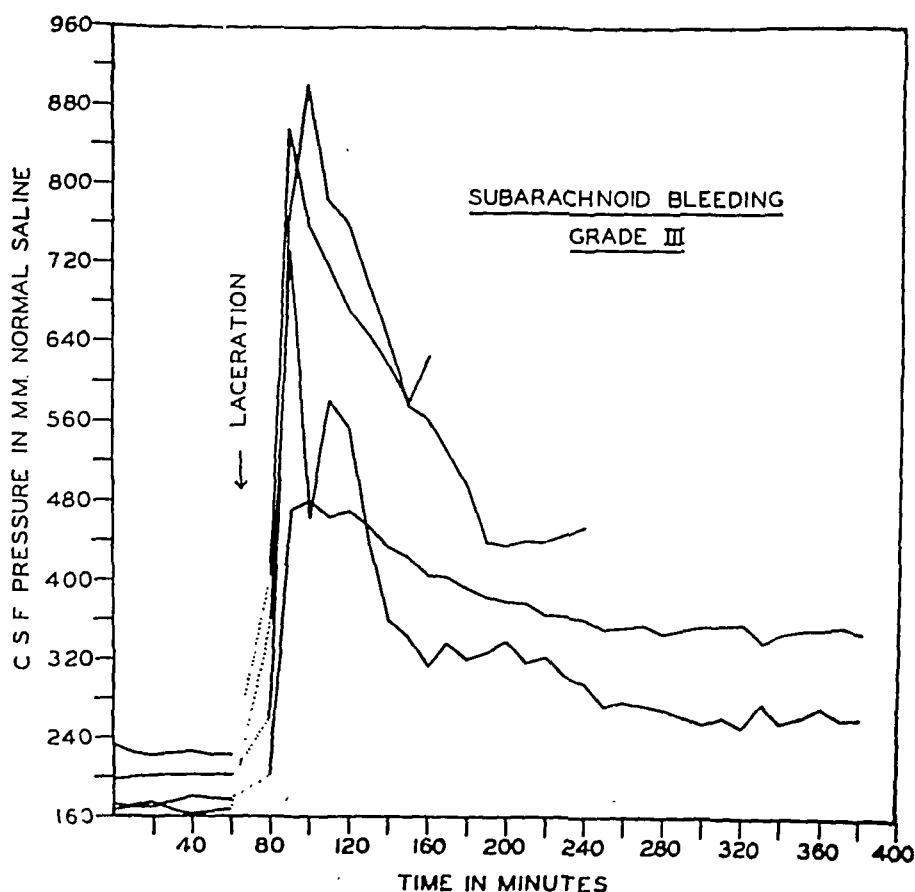


CHART 3.—Laceration experiment. Massive subarachnoid bleeding. Note that the scale of this chart has been halved as compared with Charts 1 and 2. Note also the rapid sharp rise to as much as 900 Mm. of saline followed by a slower drop and a later sustained elevation.

After the replacement of 1.5 cc. of cerebrospinal fluid by the same quantity of defibrinated, whole blood, the cerebrospinal fluid pressure rises steadily (Chart 6). This rise occurs at about the same rate in all experiments except one, in which, after a typical early rise, a slight drop from the maximum pressure occurs.

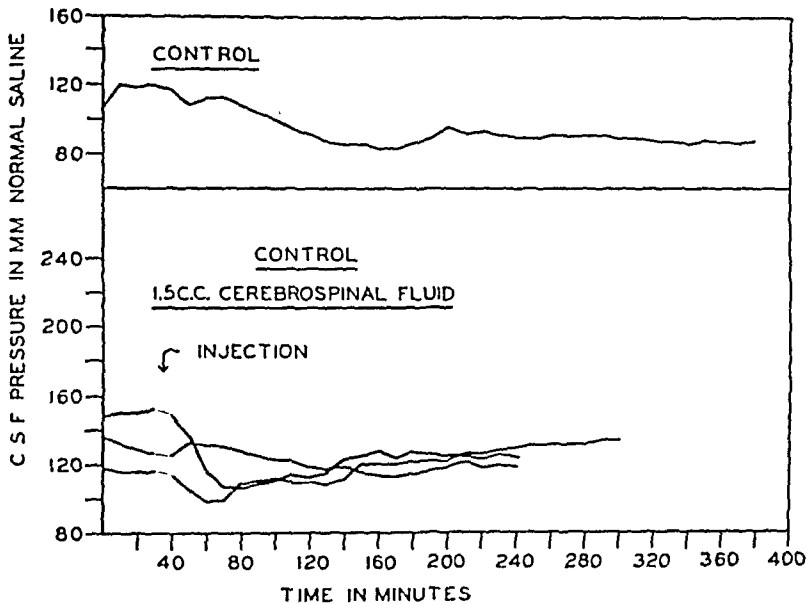


CHART 4.—Replacement experiment control. The upper curve represents the cerebrospinal fluid pressure in the anesthetized animal without other procedure. The lower curves represent withdrawal from and immediate reinjection into the cisterna magna of 1.5 cc. of cerebrospinal fluid. The arrow in this and succeeding charts represents the time at which injection was made.

After the replacement of cerebrospinal fluid by a suspension of washed erythrocytes, obtained from 1.5 cc. of whole blood, there is no rise of cerebro-

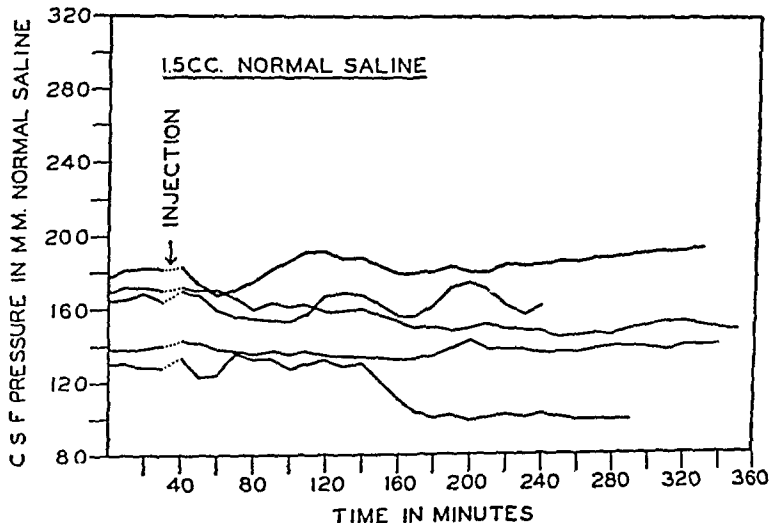


CHART 5.—Replacement experiment control, 1.5 cc. of normal saline.

spinal fluid pressure for as long as five hours (Chart 7). The individual curves differ from those of the control experiments only in slightly greater irregularity of pressures. One curve shows a definite rise in pressure for which no proven explanation can be offered. Accidental bleeding, unde-

tected on account of discoloration already present from the injected red cells, offers a possible solution.

Three experiments were performed with repeated estimations of cerebrospinal fluid pressure at one or two day intervals for as long as five days after the introduction of washed red cells. In no instance was there observed any

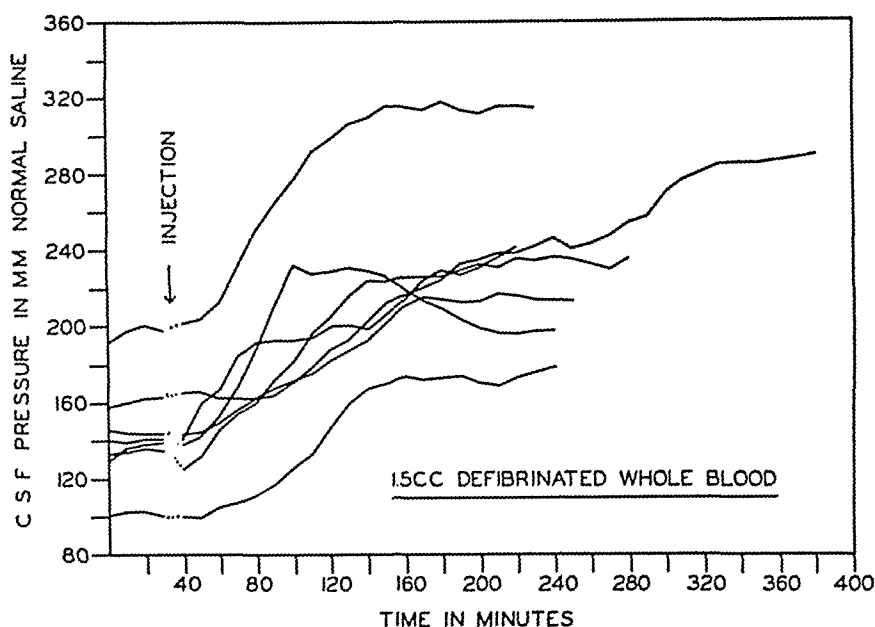


CHART 6.—Replacement experiment, 1.5 cc. defibrinated whole blood. Note consistent rise of cerebrospinal fluid pressure. One curve after a typical initial rise shows a tendency to fall.

increase over the original cerebrospinal fluid pressure. These experiments are not reported in detail because of the possibility of leakage of cerebro-

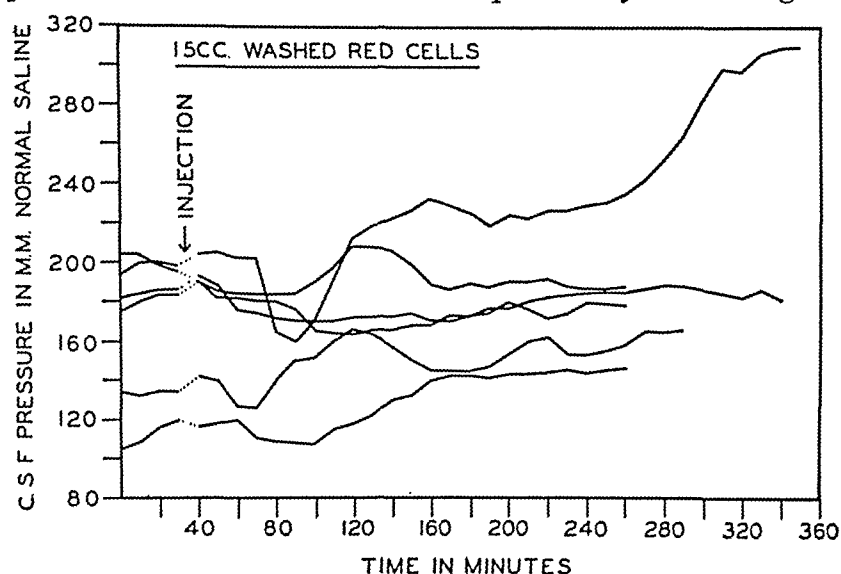


CHART 7.—Replacement experiment, washed red cells from 1.5 cc. of blood. Note somewhat irregular character of curves without consistent tendency towards elevation of pressure. One curve shows a definite rise in cerebrospinal fluid pressure.

spinal fluid from earlier punctures and because of lack of uniformity from day to day in anesthesia and water balance.

After the replacement of cerebrospinal fluid by the hemolyzed red cells from 1.5 cc. of blood, the cerebrospinal fluid pressure rises in contrast to its behavior when the intact cells are introduced (Chart 8).

After the replacement of 1.5 cc. of cerebrospinal fluid by 1.5 cc. of blood serum, the cerebrospinal fluid pressure rises with great regularity (Chart 9). The angle of elevation is somewhat greater than that when whole blood is introduced and markedly greater than that when hemolyzed red cells are introduced. In one experiment carried out for ten hours, no drop in pressure occurred.

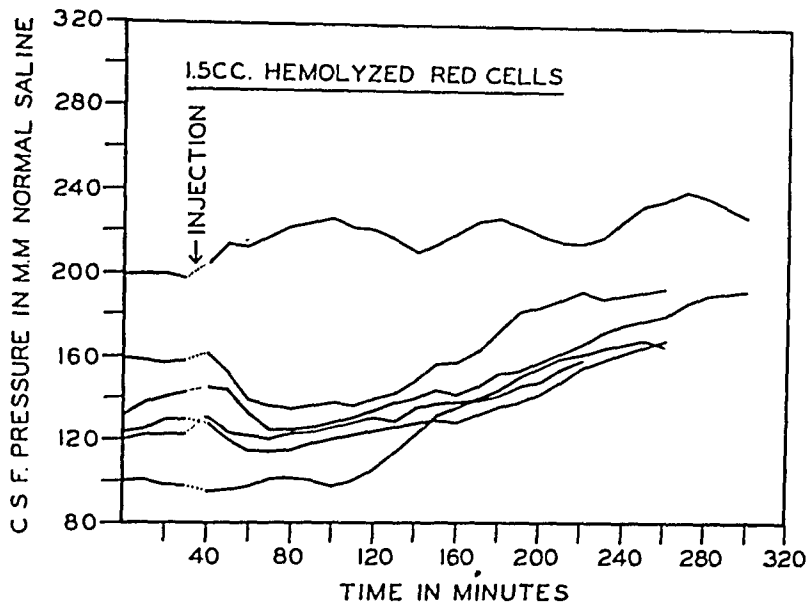


CHART 8.—Replacement experiment, hemolyzed red cells from 1.5 cc. of blood. Note slight elevation of cerebrospinal fluid pressure.

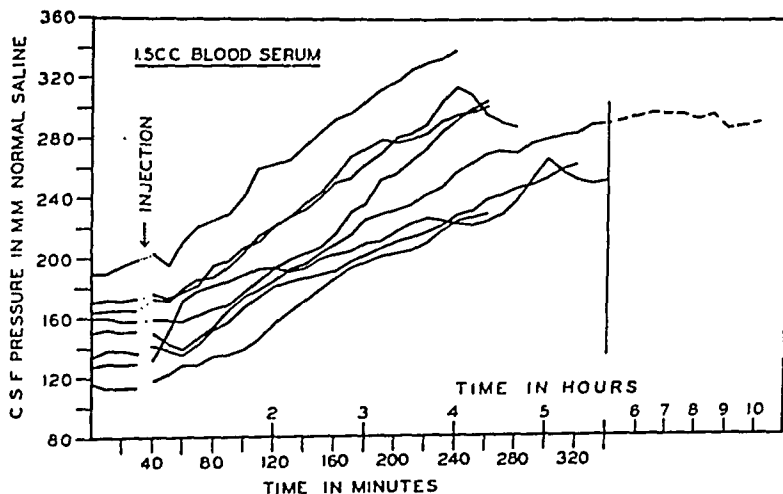


CHART 9.—Replacement experiment, 1.5 cc. of blood serum. Note regularity of rise in cerebrospinal fluid pressure which is greater than in any previous experiment. In one experiment, observation continued over ten hours shows a sustained elevation of pressure without tendency towards further rise or fall.

When the amount of blood serum so introduced is increased to 3.0 cc., the rise of cerebrospinal fluid pressure is markedly increased both in rate and in ultimate elevation (Chart 10).

Comparison of these differences in reaction of the cerebrospinal fluid pressure can best be made by comparing the average curves following the introduction of blood and its constituents (Chart 11).

Histologic Findings.—Pathologic changes in the material studied from the replacement experiments were limited to the meninges. No evidences of

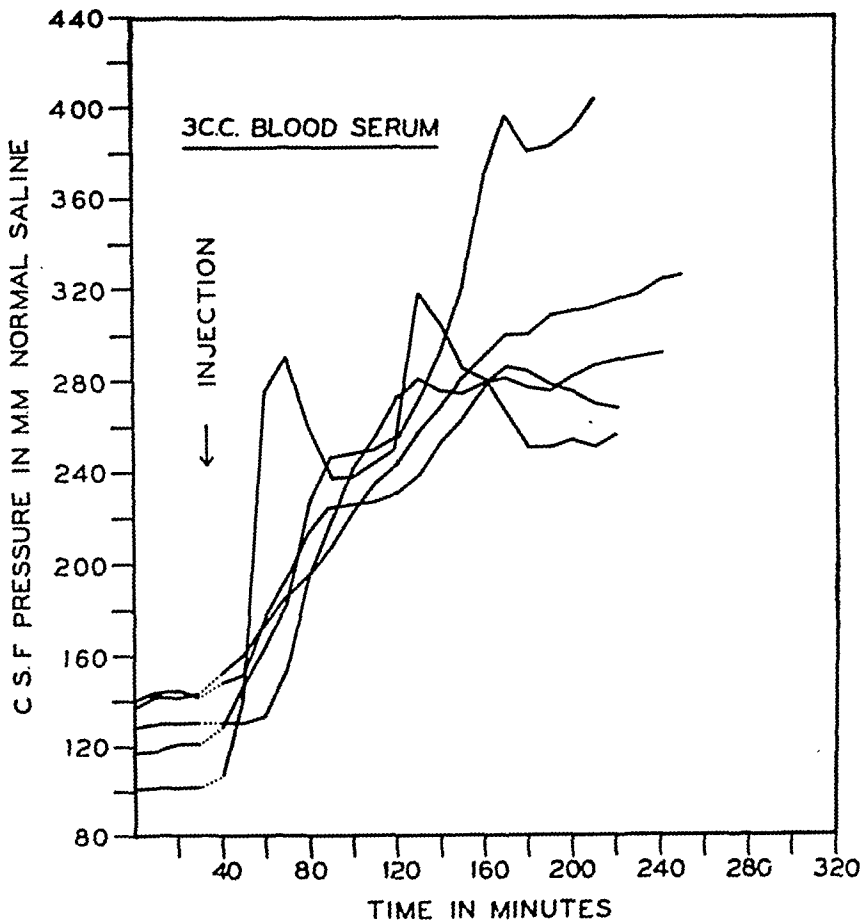


CHART 10.—Replacement experiment, 3.0 cc. of blood serum. Note sharper angle of rise and greater ultimate elevation than those recorded in Chart 9.

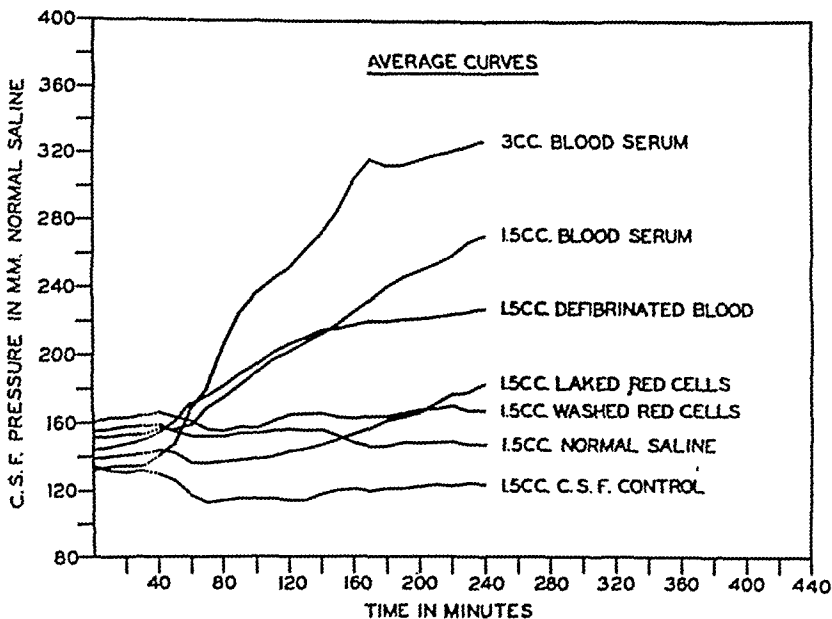


CHART 11.—Replacement experiments, average curves. The curves are constructed by averaging, at ten-minute intervals, the pressure readings from the individual experiments recorded in Charts 4 to 10 inclusive.

trauma, inflammation or edema were found within the substance of the brain in any instance.

The typical meningeal changes observed consisted of infiltration of the arachnoid and of the pia with monocytes, lymphocytes, and occasional polymorphonuclear leukocytes. A striking variability of reaction, both in incidence and distribution, was evident. For instance, five out of six brains studied following the injection of 1.5 cc. of blood serum showed a slight to moderate inflammation, whereas the sixth brain showed almost as intense a reaction as was observed in any experiment. Particularly in those instances of less reaction, the distribution of the areas of inflammatory change was irregular. Large areas of the meninges appeared entirely normal. The areas of pathologic change tended to occur most frequently about the base of the brain near the point of cisternal puncture.

A rough determination of the average intensity of the cellular reaction in each group of controls and experiments was attempted (Table I). It is realized that such averages are only approximate on account of the variations in incidence already cited.

TABLE I

COMPARISON BETWEEN CEREBROSPINAL FLUID PRESSURE RISE AND AVERAGE ESTIMATED INTENSITY OF CELLULAR INFILTRATION OF MENINGES

Exp.	No. Brains	C. S. F. Pressure Rise	Meningeal Inflammation
Control.....	5	0	+
Washed R. B. C.....	6	0	++++
Laked R. B. C.....	3	+	++++
Whole Blood.....	4	++	++++
Serum, 1.5 cc.....	6	+++	++
Serum, 3.0 cc.....	4	++++	++

DISCUSSION.—The three types of cerebrospinal fluid pressure curves in the three grades of subarachnoid bleeding following experimental laceration of the brain cannot be interpreted with entire satisfaction. The absence of pressure rise in the absence of gross subarachnoid bleeding seems significant as indicating no effective increase of brain volume from intracerebral clot or from possible traumatic edema. The sharp rise when moderate bleeding occurs may be ascribed to the increase of volume due to the effusion of blood, which is unquestionably the cause of the enormous rise when massive bleeding occurs. The succeeding drop in the latter curve probably represents adjustment of intracranial blood volume, and perhaps of cerebrospinal fluid volume, to this additional content of the closed space. It is noted, however, that a sustained elevation is established after this presumed adjustment has taken place. This observation led to the replacement experiments in an attempt to determine whether some added factor besides volume increase may be responsible for increased cerebrospinal fluid pressure in the presence of bleeding.

Such an added factor is suggested by the behavior of the cerebrospinal fluid pressure after the injection of whole blood, hemolyzed red cells and

blood serum. On account of the contradiction offered by the results of these experiments to current surgical opinion, it is important to repeat that the intact red cells are not effective in elevating cerebrospinal fluid pressure during the first few hours.

The definition of the factor common to the three effective materials must be attempted and the mechanism of its effect on cerebrospinal fluid pressure considered. Following the injection of any alien material into the cerebrospinal fluid spaces, under conditions in which the content of the spaces is not immediately altered, the pressure may rise as the result of three fundamental changes, namely, (1) an increase in the volume of the brain from edema, (2) an increase in the blood volume within the cranial cavity, and (3) an increase in the amount of cerebrospinal fluid.

Neither an increase of volume of the brain from edema nor an increased intracranial blood volume seems to be related to the rise of cerebrospinal fluid pressure in these experiments. If either of these phenomena occurs, one would expect it to be expressed in rises of pressure in the control and particularly in the washed red cell experiments. The histologic studies (Table I) suggest that the red cells are among the most irritative of the materials injected. None of the brains presented histologic evidence of edema. An increase in blood volume should not give a sustained elevation of pressure over a period of ten hours (Chart 9), nor should the rise in pressure be so gradual.

It seems logical, therefore, to assume that the phenomena recorded are the result of increase in the amount of cerebrospinal fluid. Under the conditions of these experiments, such an increase could result either from inflammation or from an increase in the osmotic pressure of the fluid.

That inflammation may occur is shown by the present microscopic studies as well as by the work of Essick³ and Bagley.² Table I, however, demonstrates no correlation between the magnitude of rise of cerebrospinal fluid pressure and the degree of inflammatory reaction.

This finding is emphasized by several isolated observations. In the instance already cited from the group of experiments with 1.5 cc. of serum, an inflammatory reaction of great intensity in one animal was accompanied by no more prompt, more rapid or more marked rise in pressure than occurred in the remaining five animals in which the reaction was slight. In a single control in which cerebrospinal fluid was removed and reinjected, the meninges showed an intense purulent meningitis. In this instance no pressure rise occurred. In the animal injected with 3.0 cc. of serum that showed the most marked pressure rise of the entire series, the inflammatory reaction was slight to moderate in degree.

If it is then concluded that, although inflammatory changes occur, they are not causally related to an increase in the volume of cerebrospinal fluid, there remains the factor of osmotic pressure to consider. The differences in amount of cerebrospinal fluid pressure increase with the injection of different substances may be expressed in terms of percentage change (Chart

12). The most striking quantitative relationship thereby demonstrated is the almost exact doubling of the pressure rise with the doubling of the amount of serum injected. The failure of the pressure to rise as high following the injection of 1.5 cc. of defibrinated whole blood, as following the injection of an equal quantity of serum, is explained by the presence of red cells, previously shown to be inert. These quantitative relationships are entirely consistent with the behavior of an osmotic process. The difference in pressure response to the injection of washed red cells and laked red cells is explained by the fact that hemoglobin can exert an osmotic effect in the latter instance and not in the former. Inasmuch as the serum proteins, par-

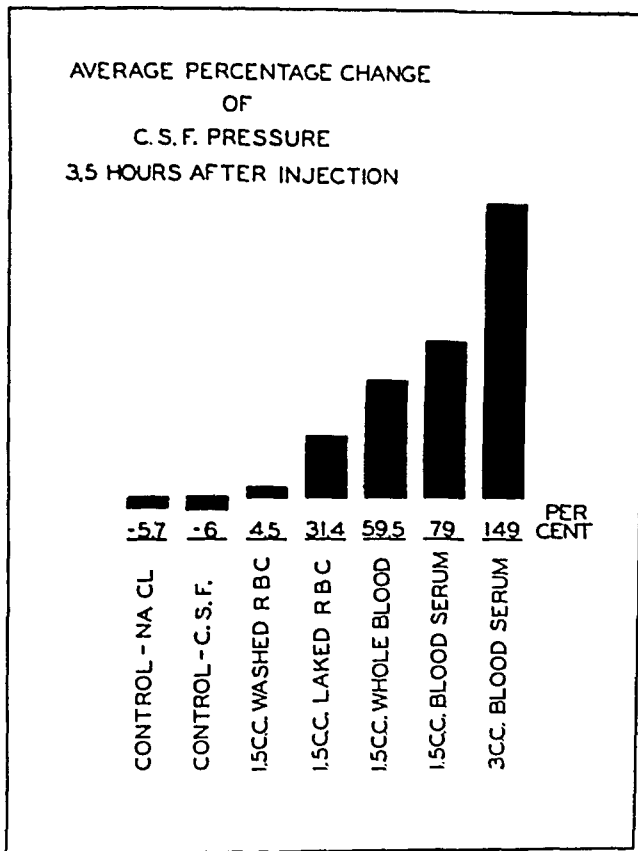


CHART 12.—Replacement experiments. The percentage values here shown were calculated from Chart 11. They represent the average amount of rise or fall of cerebrospinal fluid pressure expressed as a percentage of the average original pressure in each group, at the end of three and one-half hours.

ticularly the serum albumin, are responsible for the maintenance of the normal osmotic tension of the circulating blood, it is highly probable that the introduction of these proteins into the cerebrospinal fluid will upset its normal osmotic balance. This conception agrees with Howe's⁶ statement and is confirmed by the recent experiments of Weed.⁷

The clinical application of this study relates to the problem of increased intracranial pressure. Although the clotting elements are not present in the blood introduced experimentally, yet there seems to be no reason to expect

that the serum proteins of blood in the subarachnoid space of the patient would not behave just as they have apparently behaved in these experiments. In other words, in any case with blood in the cerebrospinal fluid, an increase in cerebrospinal fluid pressure may be due to two factors: the increase in volume due to addition of blood and the increase in volume due to osmosis. That the phenomena here reported may have clinical significance is indicated by the fact that the introduction of 3.0 cc. of serum into the dog's cisterna after the withdrawal of 3.0 cc. of cerebrospinal fluid will elevate the cerebrospinal fluid pressure to an average level of 340 Mm. of normal saline.

It is unwise to formulate any practical conclusions in regard to the treatment of hemorrhage into the subarachnoid space. Although apparently logical procedures might be suggested, the unknown factors operative in the individual case are still too many and too complex to permit therapeutic generalizations. Certainly any inclusive program for the treatment of increased intracranial pressure must take into consideration the phenomena here described.

CONCLUSIONS

(1) In experimental laceration of the brain in the dog, the cerebrospinal fluid pressure varies directly with the amount of blood that escapes into the subarachnoid space, and not with the amount of bleeding within the cerebrum.

(2) In spite of the previous withdrawal of an equal quantity of cerebrospinal fluid, a rise in cerebrospinal fluid pressure occurs in the dog following the introduction of the following substances into the cisterna magna: (1) a solution of hemoglobin; (2) defibrinated blood; and (3) blood serum.

(3) The introduction of twice the quantity of blood serum will approximately double the percentage rise of cerebrospinal fluid pressure.

(4) The introduction of washed red cells produces no increase in cerebrospinal fluid pressure over a period of as long as five hours.

(5) Microscopic study of the brains following the partial replacement of cerebrospinal fluid by blood and its separate constituents reveals inflammatory changes, which are not correlated with cerebrospinal fluid pressure changes.

(6) It is probable that the phenomena reported are the result of an increase of osmotic pressure of the cerebrospinal fluid due to the introduction of blood proteins.

(7) The approach to the problem of increased intracranial pressure must include consideration of the phenomena of osmosis as operative in bloody cerebrospinal fluid.

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REACTIONS FOLLOWING OPERATIONS FOR HYPERTHYROIDISM

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AMONG the achievements of modern surgery in the treatment of exophthalmic goiter, perhaps the most tangible, and certainly the most gratifying, has been the remarkable reduction of the mortality. A comparison of the mortality occurring among patients operated upon at The Mayo Clinic for exophthalmic goiter during the last five years of the preiodine period (1918 to 1922, inclusive) with that among patients operated upon during the past 12 years (1924 to 1935, inclusive), shows that while of 3,636 patients who were operated upon in the former period, 119 died, or a mortality of 3.27 per cent; of 9,223 patients who were operated upon in the latter period, only 76 died, or a mortality of 0.82 per cent.

This, however, tells only part of the story, for many more patients with exophthalmic goiter have been saved than is indicated by the difference in the surgical mortality. In the same preiodine period referred to, the percentage of patients who died before they could be prepared for operation (2.06 per cent) nearly equaled the number who died following operation, whereas in the latter period this figure was reduced to 0.34 per cent. In addition, during the preiodine period, when in approximately two-thirds of the cases preliminary ligations of the thyroid vessels were necessary to prepare patients for subtotal thyroidectomy, there was an interim mortality among patients who had returned home following such procedures, which, though it could not be estimated accurately, was not inconsequential. Since, today, the need for preliminary ligation is reduced to a very small percentage of the cases, this interim mortality has been virtually eliminated. It becomes apparent, therefore, that the total death rate for exophthalmic goiter during the preiodine period was at least eight times greater than it is today; or to express it in different terms, today, of every eight patients with exophthalmic goiter who formerly would have died, seven are saved.

Measured, then, by the results attained only a score of years ago, the amazingly improved results of today can be justly viewed with pride and enthusiasm. However, in our rejoicing it is important that we be on guard lest excessive enthusiasm lead us complacently to accept the present results as the final limit of progress. That there are still unsolved problems associated with the treatment of exophthalmic goiter is evident when the surgical mortality of this disease is compared with that of adenomatous goiter without hyperthyroidism (simple goiter), the mortality for the former condition being approximately ten times greater than that for the latter. The cause of this higher mortality among patients with exophthalmic goiter can be ac-

counted for in some instances by the presence of visceral injuries sustained prior to operation as the result of prolonged hyperthyroidism. In other instances in which patients die following operation the cause of death cannot be adequately explained by the anatomic findings at necropsy, and we are forced to ascribe death in such cases to acute hyperthyroid reactions. Although the problems created by these factors are not today as pressing as they formerly were, they should not be lost sight of. Instead they should be kept in the foreground constantly to challenge our best efforts.

In analyzing the records of the 76 patients with exophthalmic goiter who have died at the clinic following operations since the standardization of iodine treatment, it is not always possible to determine the principal cause of death, since in many instances death is not the result of a single factor but of a combination of two or more factors. However, such an analysis does permit of a general classification of the principal surgical hazards into three groups: (1) those connected with the operative procedure; (2) those dependent on the presence of a coexisting or associated disease, and (3) those inherent in the disease of exophthalmic goiter itself.

The first group of hazards includes not only accidents of technic, which are for the most part avoidable, but also errors of surgical judgment, including, in particular, the decision as to when to operate and the selection of the proper surgical procedure. In about 10 per cent of the cases in which death occurred, the operation was complicated by a technical mishap. While these errors were not necessarily of a nature to cause death, they must be considered as contributing factors.

The second group of hazards is encountered in cases in which other diseases are associated with exophthalmic goiter. This factor of associated disease plays a greater rôle in mortality attending operations for exophthalmic goiter than in that attending operations for many other diseases. It is not because the incidence of associated disease is necessarily higher among patients with exophthalmic goiter, but rather it is because operation in these cases, in which exophthalmic goiter is complicated by another disease, is undertaken more often than on patients suffering from other surgical conditions similarly complicated. Rarely does the presence of associated disease constitute a definite contra-indication to operation in cases of exophthalmic goiter; on the contrary, the indications for operation often become more urgent, since relief of the hyperthyroidism is either beneficial to the associated disease or is necessary before its proper treatment can safely be instituted. The presence of an associated disease, including active tuberculosis, brain tumor, angina pectoris, carcinoma of the suprarenal glands with metastasis, pyelonephritis, Addison's disease and Parkinson's disease, constituted the principal factors in 10 per cent of the deaths in this series.

The third group of hazards constitutes a problem far more complicated and less tangible than the others and represents the most important one in the surgical mortality in exophthalmic goiter. While not always independent one of the other, the hazards inherent in the disease itself may be con-

veniently subdivided into two classes: (1) those dependent upon the presence of visceral injuries, and (2) those dependent upon postoperative metabolic reactions. Of the visceral lesions found at necropsy of patients who have died of exophthalmic goiter, the most common and the most thoroughly investigated are those involving the heart and liver. Although cardiac hypertrophy⁸ and dilatation are not uncommon findings at necropsy, rarely do patients with exophthalmic goiter die of congestive heart failure. What contributing influence these complications have on the operative mortality cannot be accurately evaluated. Because of their relatively irreparable nature, the hepatic changes are perhaps the more serious.

In a previous study of the pathologic anatomy of the liver, with correlated clinical findings in 107 cases of exophthalmic goiter, Beaver and I² found three types of hepatic lesions predominating: (1) acute degeneration (fatty metamorphosis, focal and central necrosis and changes secondary to stasis of blood), (2) simple atrophy, and (3) subacute toxic atrophy and cirrhosis. The lesions were intimately related in severity to the intensity and duration of the hyperthyroidism. Since it was estimated that in approximately 40 per cent of these cases the severity of the lesion was sufficient to impair function, it is logical to conclude that hepatic injury has a significant influence on the mortality in exophthalmic goiter. Of the 53 cases in this series in which necropsy was performed, the pathologist reported gross anatomic changes in the liver or heart, or both, in 26 cases.

The surgical problems involved by these factors are (1) one of prevention, and (2) preoperative recognition and treatment. Since the development of secondary lesions in the liver and heart are largely dependent on the intensity and duration of hyperthyroidism, they can be virtually prevented by the institution of prompt surgical treatment. The importance of the duration of the disease as an influence in the surgical mortality is forcibly emphasized when the average duration of the disease in all cases of exophthalmic goiter in which patients were operated on since 1923 is compared to that in those cases in which the patients died. For the entire series the average duration of the disease was 17.70 months, whereas for the group who died it was 28.09 months.

While the presence of visceral injuries can commonly be detected prior to operation by means of clinical tests of hepatic efficiency, the electrocardiogram, and other clinical means of investigation, their significance on the operative hazard cannot always be accurately determined, since a very high percentage of patients with known visceral injuries easily endure the operation. However, knowledge of the presence of such visceral injuries is important, since it clearly indicates that additional measures of safety may be required in the preparation and treatment. These include, in particular, prolongation of the usual period of preparation and the employment of stage procedures in resection of the goiter.

The clinical response of the patient with exophthalmic goiter to the surgical procedure, which is manifested in part by an intensification of already

accelerated metabolic processes, commonly referred to as the "postoperative reactions of hyperthyroidism," are today much less frequent and severe than they were in the preiodine period. This change is particularly noticeable in the virtual elimination of the typical postoperative crises of the disease, which resemble the picture of an overwhelming intoxication; formerly these crises were frequently precipitated even by minor procedures, such as ligation or injection of a few cubic centimeters of quinine-urea solution into the gland. Commonly the reaction begins within a few hours after completion of the operation and it is manifested by increasingly marked tachycardia, intense flushing and sweating, nausea, persistent vomiting, rapid respirations, progressive mental agitation and restlessness, which causes the patient to thrash about in bed almost incessantly. The temperature rises with the onset of the reaction and within a few hours reaches from 102° to 104° F. or higher. Frequently, delirium, prostration and coma supervene. While occasionally the symptoms abate after two or three days, in most instances death follows in from 12 to 48 hours and at necropsy no anatomic changes can be found to account for it. The picture is almost identical to that of the spontaneous crisis of the disease, with the difference that in the latter the course is less rapidly progressive and is usually unaccompanied by fever, unless complicated by infection, until the terminal stages.

The abnormal physiologic process involved in the precipitation of a reaction is not fully understood. According to the theories which seem the most tenable the mechanism by which the reaction is produced is explained: (1) by the sudden increase in the amount of thyroid secretion (either normal or abnormal) in the tissues, and (2) by hypersecretion of epinephrine. Since increased oxidation in exophthalmic goiter is caused by increased thyroid secretion, and since the clinical manifestation of the reaction can be explained at least in part by an acceleration of the processes of oxidation, it is logical to assume, in the absence of proof to the contrary, that postoperative reactions are caused by a further increase in thyroid secretion. That surgical manipulation of the thyroid gland is not necessary to precipitation of such a reaction is evidenced by the fact that reactions have been produced in cases of exophthalmic goiter by operations performed for conditions other than goiter. However, there are reasons to 'doubt' that the thyroid gland is capable of suddenly discharging sufficient thyroxin to produce such marked postoperative reactions as are sometimes seen. There is evidence to indicate that the intensity of the response to intravenous injection of thyroxin varies inversely with the patient's basal metabolic rate. Thus Thompson and his associates¹⁴ estimated that the intravenous injection of 10 mg. of thyroxin produces about seven times as much effect when given to patients whose basal metabolic rate is —40 per cent as when given to patients with normal levels of metabolism. In 1920 Plummer administered intravenously, to several patients with exophthalmic goiter whose basal metabolic rate was +75 per cent or greater, 15 mg. of thyroxin every second day for four doses.

These injections resulted in no apparent response, either in elevation of the basal metabolic rate or in the development of any clinical effects.

The theory that these reactions are caused by hypersecretion of epinephrine, induced by physical and emotional factors associated with the operation, is supported in part by the following experimental and clinical observations: (1) the functional activity of the suprarenal medulla is increased by pain and other major emotions, as shown by Cannon,^{3, 4} (2) injection of adrenin induces secretory activity of the thyroid gland, as shown by Cannon and Cattell,⁴ (3) thyroxin renders the sympathetic nervous system more excitable to the action of epinephrine in raising arterial blood pressure, as shown by Levy,¹⁰ (4) the symptoms of hyperthyroidism abate after denervation of the suprarenal glands, according to Crile,⁵ and (5) the response of a patient with hyperthyroidism to the subcutaneous injection of epinephrine hydrochloride is similar in nature to the hyperthyroid reaction following operation, as reported by Goetsch and Ritzmann.⁶

While today the typical crisis (both postoperative and spontaneous) is uncommon, there still occurs, perhaps after every operation for active exophthalmic goiter, some reaction of hyperthyroidism. When the patient has been adequately prepared with iodine the reaction is commonly so mild that, clinically, it can scarcely be distinguished from the normal postoperative response of a patient with simple goiter, and it differs only in increased sweating, a moderate rise in temperature and pulse rate, and perhaps in the development of intermittent irregularity of cardiac rhythm. As a rule such symptoms do not develop immediately after operation but are delayed for six to 12 hours or even longer, and they usually subside within from 24 to 48 hours without having materially influenced the patient's convalescence. The more severe hyperthyroid reactions seemingly differ from the milder ones only in the intensification of the symptoms, and usually they are not accompanied by the extreme mental agitation, the restlessness and the general toxic state which characterize the typical crisis of the disease such as formerly was observed among patients who had not received iodine. Unlike the typical crisis of the preiodine period, the intense metabolic reactions as seen today do not usually appear sufficient in themselves to cause death. In some cases, death under these circumstances can be more readily explained on the basis of the failure of the liver, and perhaps other vital organs already impaired, to respond to the additional load imposed by the reaction. In other cases death is not infrequently attributable to infectious processes activated because of lowered resistance of the patient induced by the reaction.

Today, the intense metabolic reactions are for the most part limited to a relatively small group of cases of severe or relatively severe hyperthyroidism in which there is a large firm goiter of long duration. Many children with exophthalmic goiter also fall into this group. Since the condition of the patients in this group cannot be improved materially by any known measure short of partial removal of the goiter, and since the operative mortality among them is relatively high, there is obviously the need of some other

therapeutic measure which will either abate the intensity of the hyperthyroidism or will fortify the patient better to endure the postoperative reaction.

From the field of research into the relationship of the thyroid gland to other organs of internal secretion there have already come sufficient clues to further the hope that a final solution of some of these problems will be found. That the suprarenal cortex has some inhibiting effect on the thyroid gland seems to be well established. Many investigators have shown that enlargement of the suprarenal gland follows administration of thyroid substance. Marine and Baumann^{11, 12} and others have suggested that, in exophthalmic goiter, the suprarenal gland exerts an influence which is antagonistic to overactivity of the thyroid gland. They have prepared an extract from the suprarenal gland and employed it in cases of hyperthyroidism, but without significant improvement of the patient.

Kendall⁹ has suggested administration of sodium chloride and sodium bicarbonate, or sodium citrate, together with cortin as a means of combating postoperative hyperthyroid reactions. This suggestion is based on the following reasoning: Koelsche⁹ has shown that in adrenalectomized animals, active preparations of the cortical hormone exerted a sparing effect on the breakdown of protein. Allers¹ has extended this observation and found that sodium chloride alone lessens the severity of the breakdown of protein after the administration of thyroxin. In addition, Allers has demonstrated that an adrenalectomized animal can be maintained in a normal condition, without cortical hormone, provided sufficient sodium chloride and sodium bicarbonate (or sodium citrate) are given to replace the daily loss of these salts.

This work, which has been confirmed by Harrop and his co-workers,⁷ emphasizes the close relation between the action of the cortical hormone and mineral metabolism, particularly sodium salts. In the condition of crisis which is observed in acute cases of exophthalmic goiter, it seems probable that in many cases there is a negative balance of sodium salts, particularly sodium chloride. The administration of sodium chloride and sodium bicarbonate is indicated; but, provided the suprarenal cortex has been stimulated to the point of exhaustion, the administration of sodium salts alone might give only temporary relief. By the injection of sodium chloride and sodium bicarbonate, or sodium citrate, together with a potent extract of the suprarenal cortex, the deficiency in mineral metabolism would be remedied and the possible deficiency in cortical hormone relieved.

Since mild and moderately severe reactions commonly subside spontaneously within from 24 to 48 hours, the application of this form of treatment has been limited to four cases in which postoperative reactions of severe intensity developed and the patients were considered to be critically ill. Of these four patients, three had been operated upon for exophthalmic goiter, the remaining one for adenomatous goiter with hyperthyroidism. In two of the cases of exophthalmic goiter marked clinical improvement apparently resulted from the intravenous administration of a solution of 5 per cent sodium citrate and 0.9 per cent sodium chloride, to which was added an active prep-

aration of cortin. One patient, a girl, aged 12, received two injections of 850 cc. each of this salt solution, on successive days, containing 5 cc. and 10 cc., respectively, of cortin. The other, an adult, received two injections, eight hours apart, of 500 cc. of the salt solution containing 15 cc. of cortin. Both patients made a satisfactory recovery. Unfortunately in the first case estimations of the chemical constituents of the blood were not undertaken. In the second case the values for blood potassium, chlorides and sodium were determined before operation and at frequent intervals after operation. The value for blood potassium on the second morning after operation was slightly elevated, but it returned to normal following the intravenous injection. The values for blood chlorides and sodium remained normal throughout the period of observation.

It is apparent that no conclusions regarding the value of administering sodium chloride and sodium citrate together with a potent extract of suprarenal cortex are warranted from this very limited experience, and this form of treatment is mentioned here only in the hope that from this or from other fields of investigation there may be developed a treatment which will prove of value in preventing or combating the postoperative reactions of hyperthyroidism which today represent a most important factor in the surgical mortality in a small group of patients with exophthalmic goiter who cannot be made safe operative risks by measures now available.

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DISCUSSION.—DR. FRANK H. LAHEY (Boston, Mass.).—It seems to me that thyroid deaths are largely liver deaths. There are many factors which indicate this. Another thing is that some thyroid deaths each year appear to be inevitable and unavoidable.

We do about 1,000 goiters a year; we have performed some 14,600 operations upon approximately 12,000 people. Certainly one should be able to avoid mortality, but we do not seem to have been able to do it. Doctor Pemberton and Doctor Crile have probably performed more operations, and many of you have done as many, but we all still have mortalities with hyperthyroidism. It, therefore, becomes extremely important, I think, for us to concentrate on what the factors are that are indicative of the severity of hyperthyroidism and which may predispose to a fatality.

The reason, I think, that some of these patients die liver deaths is because those who die with no operation are frequently jaundiced; they die with temperatures of 105° to 106° F.; they are benefited by the things that benefit diminished liver function, particularly fluids and glucose, and the disease is really a disease not of intoxication but of excessive combustion.

Some of the factors which are helpful in selecting risks, and thus in selecting graded operations, are of extreme importance. I would strongly urge that pole ligation not be given up. I think that because we have come to lean on iodine, we tend to believe that you do not need pole ligation. There will shortly appear in Surgery, Gynecology and Obstetrics, the results of 113 pole ligations which we have performed and analyzed postoperatively, and in 66 per cent of them there was a gain in weight, a drop in pulse, and an improvement in the nervous system. When a patient is so ill that you think a fatality is a possibility, and you have an operative procedure as minor as bilateral or single pole ligation which will make this amount of improvement, that is in two-thirds of the cases, then certainly we should not give up pole ligation.

There are one or two other points. One is that low blood cholesterol indicates severe hyperthyroidism. Another point is that we have thought, up until recently, that high blood iodine indicated high blood thyroxin. Thyroxin is 65.2 per cent iodine. It is logical to assume that the high blood iodine seen preoperatively, and which comes to normal postoperatively, is probably the iodine fraction of thyroxin. That unfortunately is not certain.

We now know from recent reports of Mr. H. J. Perkin, who has been doing the blood iodine studies in our Clinic, that out of 331 patients upon whom blood iodine studies were made pre- and postoperatively, 70 per cent had high preoperative blood iodine which came to normal postoperatively; that 30 per cent, on the other hand, had low blood iodine, which after operation rose to above normal, and later, when the metabolism came to normal, returned to normal. This, of course, is disturbing from the point of view of blood iodine possibly representing the iodine fraction of thyroxin.

One of the interesting observations in connection with these atypical findings of blood iodine, has been that without knowledge as to the blood iodine in the 70 per cent of these patients having high blood iodine and coming to normal postoperatively, multiple stage procedures were employed in but 17 per cent of the cases, while in the 30 per cent of patients having low blood iodine preoperatively, which went above normal postoperatively, 46 per cent had multiple stage procedures.

One, therefore, must presume that two features suggesting severity of hyperthyroidism are low blood cholesterol and low preoperative blood iodine. Particularly in this latter group of cases, those with low preoperative blood iodine, we must consider multiple stage operation and when we know that in 66 per cent of the patients having preliminary pole ligations, there is a drop in metabolism, a gain in weight, and a drop in pulse rate, and that in approximately 80 per cent of the patients having preliminary hemithyroidectomy followed by second stage hemithyroidectomy, there is a drop in metabolism, a gain in weight, a drop in pulse rate, then surely multiple stage procedures should be kept in vogue for the patient with severe hyperthyroidism.

DR. JOHN DEJ. PEMBERTON (Rochester, Minn.) closing.—I think Doctor Lahey is perfectly right in stressing the importance of the liver as a factor in the cause of death in these cases, but I do think that the hyperthyroid reaction probably imposes an additional burden which the liver is not able to carry on during the time.

I feel just a bit guilty in even mentioning this form of treatment without having had greater experience in its use, and I want to make myself unmistakably clear regarding one point, namely, that this form of treatment with cortin is not used as a substitute for any of the methods or measures that have proved valuable but is only used as an additional measure in the hope of preventing or checking the reactions.

PERICARDIAL RESECTION IN CHRONIC CONSTRICTIVE PERICARDITIS

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THE cure of chronic constrictive pericarditis by operation has been one of the most satisfactory chapters in the history of the surgery of the heart. The disease is admittedly a rare one, but the fact that three clinics in this country and several abroad have assembled sizable series of cases can mean only that the diagnosis is being overlooked elsewhere. The surgeon is dependent upon his medical colleagues for the diagnosis, as the few cases of the disease are found under the care of internists. They are variously mislabeled as tuberculous peritonitis, cirrhosis of the liver, valvular heart disease, or ascites of unknown origin. Dr. Paul White has presented the diagnostic problem in detail in his St. Cyres Lecture.¹ With the exception of three more recent cases included in the present report, he has presented the case histories in detail. White's historical résumé is of real interest in showing that the establishment of the condition as a disease entity far antedates Pick, whose name is commonly perpetuated as the eponym. The present communication will deal only with the surgical problem offered by constrictive pericarditis.² The details of the case histories as summarized by White will not be repeated and the discussion of diagnosis will be limited to certain aspects that bear directly upon the surgical program. In addition, the list of cases here presented does not conform to White's series to the extent that patients not operated upon by the author have been omitted. The results summarized in Table I are therefore to be considered as the personal series of one surgeon rather than a general hospital report. But as all cases entering the Massachusetts General Hospital since 1931, and found suitable for surgical intervention, have been assigned to the author through the courtesy of the staff, the report does not represent a selected group, except as noted.

SELECTION OF CASES SUITABLE FOR SURGERY. *Rheumatic Heart Disease*.—White states that "if rheumatism can cause Pick's disease it does so in only the rarest cases." This statement is in direct contradiction to the impression gained from a study of the case reports on record in the literature, particularly from European clinics. It is based on the fact that no one of the 16 patients under observation with this complaint at the Massachusetts General Hospital gave a history of rheumatic infection as an etiologic factor. As further evidence, White refers to a group of 1,000 children with rheumatic heart disease followed over a period of ten years at the House of the Good Samaritan in Boston. In not a single instance was there evidence of chronic

constrictive pericarditis, although in many of the patients episodes of acute rheumatic pericarditis had been noted.

This fact is of utmost importance to the surgeon and should lead him to question seriously the propriety of undertaking the operation in patients with rheumatic heart disease. While rheumatic infection not infrequently causes obliteration of the pericardial cavity, the evidence that these adhesions may produce the constrictive pericarditis syndrome is slight indeed.

Active Tuberculous Pericarditis.—Active tuberculosis of the pericardium may produce the entire syndrome of chronic constrictive pericarditis. The point at issue is whether operation can be effective if performed during the active phase of the infection. The reports in the literature of operations performed during this period are uniformly discouraging and confirm our personal experience.

We have, on two occasions, attempted to relieve the serious and progressive tamponade encountered as a terminal event in active tuberculous pericarditis. The nature of the pathology in both instances absolutely precluded relief by surgery. The anterior aspect of the thickened parietal pericardium was excised without difficulty. The fluid, that was in itself relatively unimportant in causing tamponade, was evacuated. The heart was small and lying free within the rigid walled cavity formed by the parietal pericardium. Its surface was covered by a dense, acutely inflamed capsule many millimeters in thickness almost completely throttling the diastolic filling of all chambers of the heart. Even a decortication of the ventricles was out of the question. Both patients died promptly, one on the operating table and the other a few hours subsequently, their lives being shortened a few days as a result of the operative procedure. A third patient has been seen recently upon whom operation was not attempted as a result of these experiences. He died within a few weeks with disseminated miliary tuberculosis. Autopsy findings confirmed our impression that decortication of the heart was impossible.

The diagnostic problem is, therefore, to recognize the active phase of the disease and postpone operative interference with the belief that the best chance for life lies in a self-limitation of the active tuberculous infection. If, and when, the activity subsides and the patient is left with a healed scar constricting the heart, surgery can be successfully undertaken. During the active infection the effects of tamponade can be somewhat controlled by repeated aspirations and diuretics. Rest, light treatment, and other general measures may be employed as in tuberculous peritonitis. The value of pneumopericardium or the possibility of oleopericardium under these conditions have not as yet been established.

The probability that many of the cases of chronic constrictive pericarditis represent healed stages of a pericarditis due primarily to tuberculosis is an important question still to be settled. Examination of the scar tissue removed at operation universally fails to establish a diagnosis of tuberculosis. On the other hand, the frequency with which calcium deposits are found, and the

unusual density of the scar tend to link the pathology with the tubercle bacillus.

The only reliable finding that distinguishes the active phase of tuberculous pericarditis from constrictive pericarditis due to a healed scar is the demon-

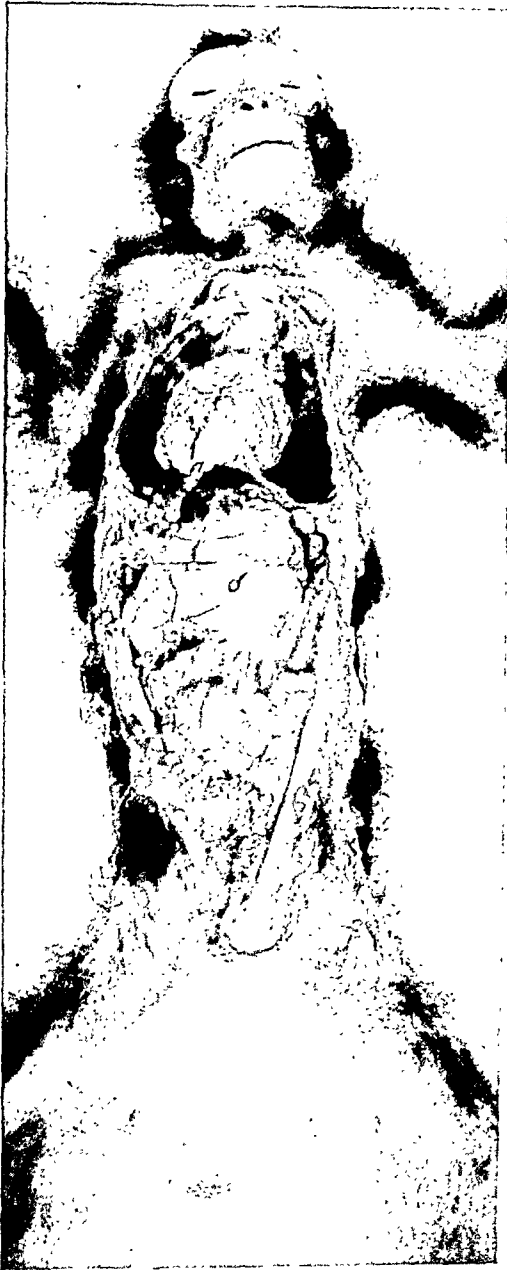


FIG. 1.—Tuberculous pericarditis in a monkey, terminating in general dissemination of tuberculosis. Peripheral edema and ascites.

stration of the tubercle bacillus in fluid aspirated from the pericardium. The sudden appearance of the syndrome in a patient with known active tuberculosis elsewhere is presumptive evidence. Fever, increasingly severe tamponade, bloody pericardial fluid, rapid sedimentation rate, and other signs of active infection are suggestive, but are occasionally met with in patients not showing active pericardial tuberculosis. In case of reasonable doubt, it is best to make a limited exploration under local anesthesia. Active infection can usually be recognized by the presence of tubercles on the inner surface of the parietal pericardium. Figure 1 demonstrates the reproduction of the disease in a monkey by injection of pieces of pericardium from one of our fatal cases into the pericardial cavity. The tamponade is manifested by the edema of the eyelids and scrotum, and the terminal dissemination of tuberculosis by the tubercles studding the omentum. The pericardium and heart formed a fused mass of tuberculous tissue.

OPERATIVE TECHNIC. *Anesthesia.*

The magnitude of the operative procedure and the necessity for complete control of the situation, should the heart itself be accidentally torn, make a general anesthetic the method of choice. Simpler operations such as the Brauer cardiolysis or exploration of the peri-

cardium by a limited chest wall resection can of course be accomplished with local anesthesia. The likelihood of opening either, or both, pleural cavities makes it desirable to employ a method of administration allowing differential pressure to be established. Any anesthetic agent that can be combined with adequate oxygen concentration is suitable. In our cases this has been ether administered intratracheally.

Position of Patient.—We have employed a dental chair, believing that a semirecumbent position gives a desirable exposure of the field and in addition tends to diminish the venous return to the heart.

Exposure of the Pericardium.—An ample chest wall window is usually attained by resecting the third, fourth and fifth costal cartilages with about one inch of the corresponding ribs. At times the sixth cartilage and rib end are also resected. No attempt is made to do a subperichondral resection of the cartilages as it is desirable to leave a flexible anterior chest wall over the liberated heart. After ligating the internal mammary vessels the margin of the sternum is exposed, allowing a liberal resection of the left half with the Lebsche sternum knife. The left pleural reflection is now mobilized and separated from the pericardium. At times this is so adherent that opening into the pleural cavity cannot be avoided. In one instance the usual "area of safety" to the left of the sternum was completely absent and the pleural reflection extended to the border of the sternum. The reflection of the right pleura can usually be identified in the upper portion of the field as it reaches the left sternal border. In one case the four major serous cavities of the body, both pleural cavities, abdomen and pericardium were opened during the course of the operation.

Removal of the Scar.—When an area of parietal pericardium has been exposed by dissection and retraction of overlying structures, it is incised preferably in the thinnest area that may overlie the left ventricle. A plane of cleavage is established between the heart muscle and the scar. The anatomic position of this plane of cleavage is not always clearly discernible but usually lies between the visceral pericardium and the layer of organized exudate that has attached itself more firmly to the parietal layer than the visceral. It is essential to the success of the operation to select a plane of cleavage that lies close to the heart muscle itself. Grasping the edge of the scar, and exerting traction during the subsequent dissection, facilitates the exposure in the more inaccessible areas.

If the scar extends laterally over the left ventricle this region should be removed as the first step. Excision may be carried as far as the phrenic nerve, but I have in no instance sacrificed this structure.

The sulcus formed by the descending branch of the left coronary artery is apt to be the site of densely adherent scar, and this region should be approached with caution to insure the preservation of this important vessel. In one instance a thickened calcified band 2 Mm. in diameter marked this sulcus. A maneuver that has been advantageous in several instances has been to establish a new plane of cleavage over the right ventricle so that the inter-ventricular groove may be approached from both sides.

A second very adherent region is the right auriculoventricular groove, in intimate association with the diaphragmatic pericardium. In many cases of the disease the mobilization of the auriculoventricular groove has been a crucial step in relieving the obstruction to right ventricular filling. Keith has shown that the free motion of the auriculoventricular groove is an important

physiologic mechanism in the action of the right heart. Every effort, therefore, should be made to free this area if it can be done with safety, and once past it the inferior cava can usually be readily exposed. Actual decortication of the auricle is a hazardous procedure owing to the thin wall of this chamber of the heart. It has been attempted in only three instances.

Dissection of the diaphragmatic pericardium and scar from the heart should be as complete as possible but in no instance has been carried to the left auricle. Here in particular one is apt to encounter plaques of calcification that extend into the substance of the myocardium. A persistent venous oozing from the heart following their liberation may require hemostasis by fine silk sutures. A thick calcified shell requires the use of rongeurs.

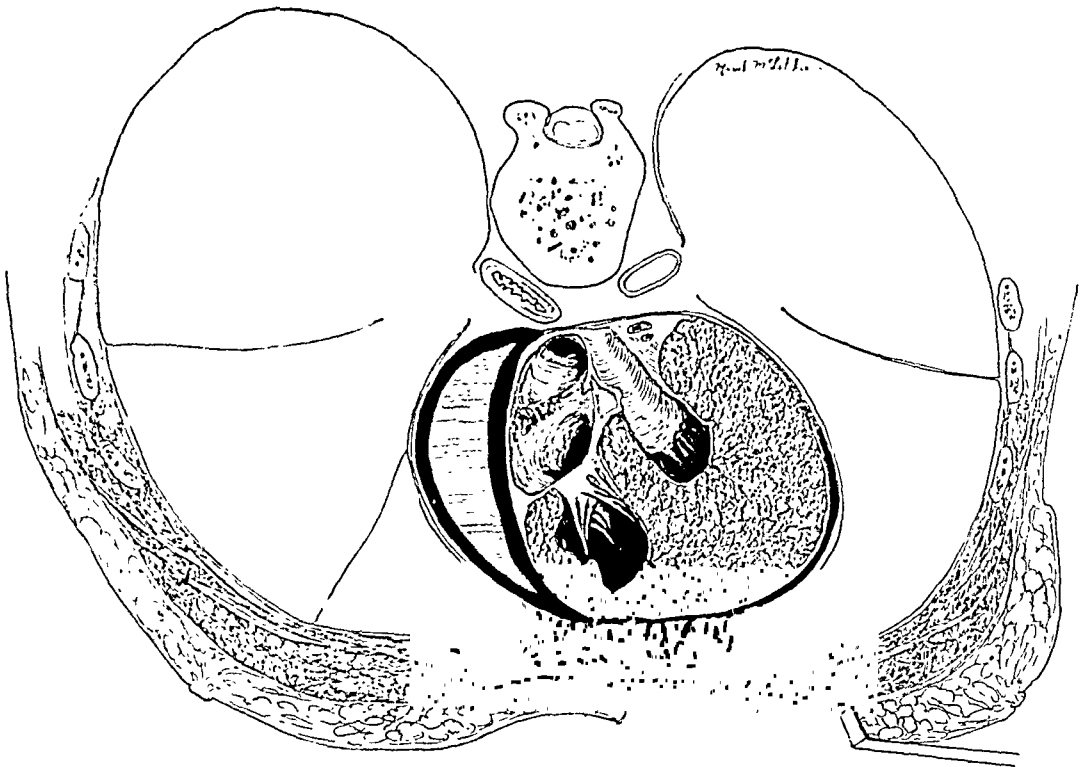


FIG. 2.—Diagram of chronic constrictive pericarditis with encapsulated fluid over right auricle and ventricle.

In general, the outer surface of the pericardium is exposed and bleeding points controlled before freeing the corresponding area from the heart.

Damage to the Heart.—Only in two instances has a chamber of the heart been entered during the operation. In one case a small wound of the right ventricle was readily repaired. In the other case decortication of the right auricle in a good line of cleavage was being carried out by cautious dissection. The tip of a pair of Hartman forceps carrying a cotton pledget plunged into the auricle. A furious hemorrhage resulted that was controlled only by a method suggested by Bigger. As the scar is freed from the heart, a generous flap is always left adjacent to the point of dissection. In such an emergency the scar is replaced on the heart and sutured to close the defect. It was only this maneuver in the case described that averted a catastrophe. In dealing

with a rigid calcified scar even this procedure might be impossible to execute as illustrated by a case reported by Winkelbauer and Schur.³ Decortication of the auricle should not be attempted in the presence of a rigid calcified envelope.

It is surprising to see how few square millimeters of scar are actually excised in relation to the surface area of the heart that is delivered by the operation. This is due to the increased diastolic filling that is of course the aim of the operation.

Encapsulated Areas of Fluid.—The obliteration of the pericardial cavity may be complete in some areas and residual pockets of fluid be found in others. When an area of encapsulated fluid exists it is important to resect

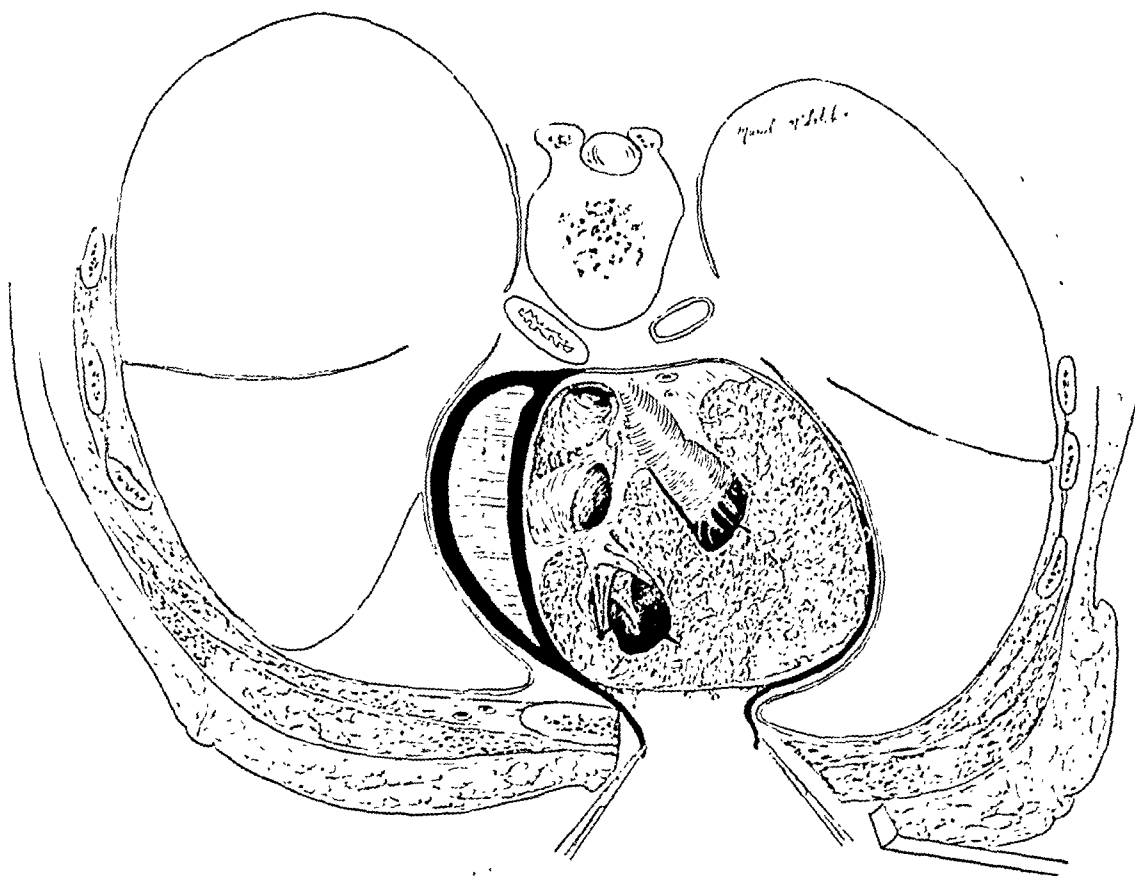


FIG. 3.—Parietal pericardium and scar dissected from left ventricle. Dense adhesions mark the margin of encapsulated fluid.

the wall of the cavity that is in contact with the surface of the heart. The removal of the parietal pericardium over such an area can be accomplished simply, but will not have the desired effect. A new line of cleavage must be established and a true decortication of the heart carried out. This is illustrated diagrammatically in Figs. 2, 3, 4 and 5, and by the operative sketches as illustrated in Figs. 6 and 7.

Opening the Pleural Cavities.—An opening may deliberately be made into the left pleural cavity if the pleura is densely adherent to the pericardium. The free margin is then sutured to the pericardium at a deeper level. The right pleura may similarly be opened in freeing the right auricle or ventricle. The amount of air that enters may be controlled by positive intratracheal pres-

sure. After the opening is closed the residual pneumathorax may be aspirated with a needle or allowed to remain if the vital capacity is not seriously reduced. The possible advantage of leaving a small pneumathorax will be discussed below.

Closure of the Incision.—After the heart has been adequately freed the muscle and skin flap is replaced to cover the defect and the incision closed. Silk is used throughout to minimize exudative healing. In only one instance has a small drain been introduced to provide an escape for blood. The danger of tamponade from an accumulation of serum does not appear to be great as blood and serum may freely diffuse into the muscle planes of the body wall and are not limited by an inelastic capsule as is the situation in penetrating wounds of the heart and pericardium.

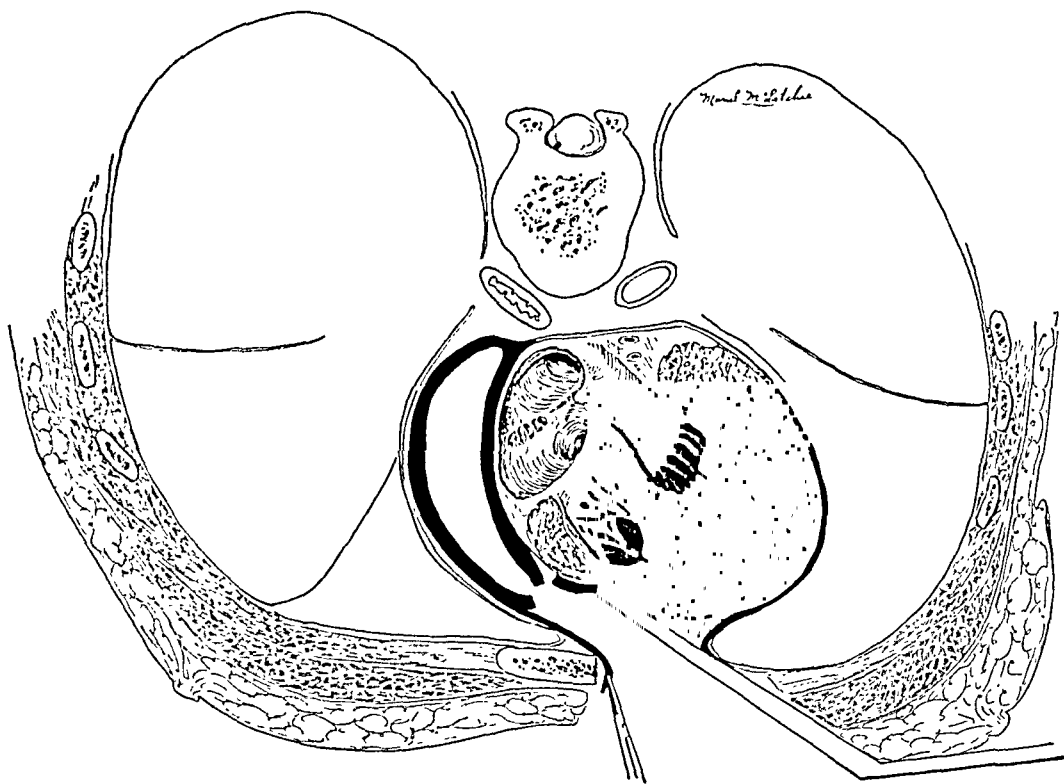


FIG. 4.—Cavity containing fluid is entered and a new line of cleavage developed to separate its inner layer from the surface of the heart.

Postoperative Care.—Transfusion has not been employed and is to be avoided because of the danger of cardiac dilatation from too great a venous return to the heart. If required, citrated blood should be administered very slowly.

An oxygen tent is used routinely after the operation but may be discontinued in a few days.

Drugs, other than diuretics, have little place in the pre- or postoperative program. A syringe containing adrenalin solution should be at hand during the operation for use if cardiac standstill be encountered. The greatest therapeutic safeguard is achieved by maintaining adequate oxygenation both during the operation and subsequently. The heart will tolerate many insults if ade-

quately supplied with oxygen, but withstands poorly any unusual strain or manipulation if attended by anoxemia.

PHYSIOLOGIC CONSIDERATIONS.—Beck has warned against a reduction in cardiac output, that he believes may be of serious degree, produced by the exposure of the heart and great vessels to atmospheric air pressure. This “pneumacardiac tamponade” has been studied extensively in the laboratory by Beck and his colleagues.⁴ In conclusion, they recommend a revival of the Sauerbruch negative pressure chamber for operations in which the heart is exposed.

Blalock⁵ has been unable to confirm the findings of Beck under slightly modified experimental conditions. Even if the experimental data of Beck be

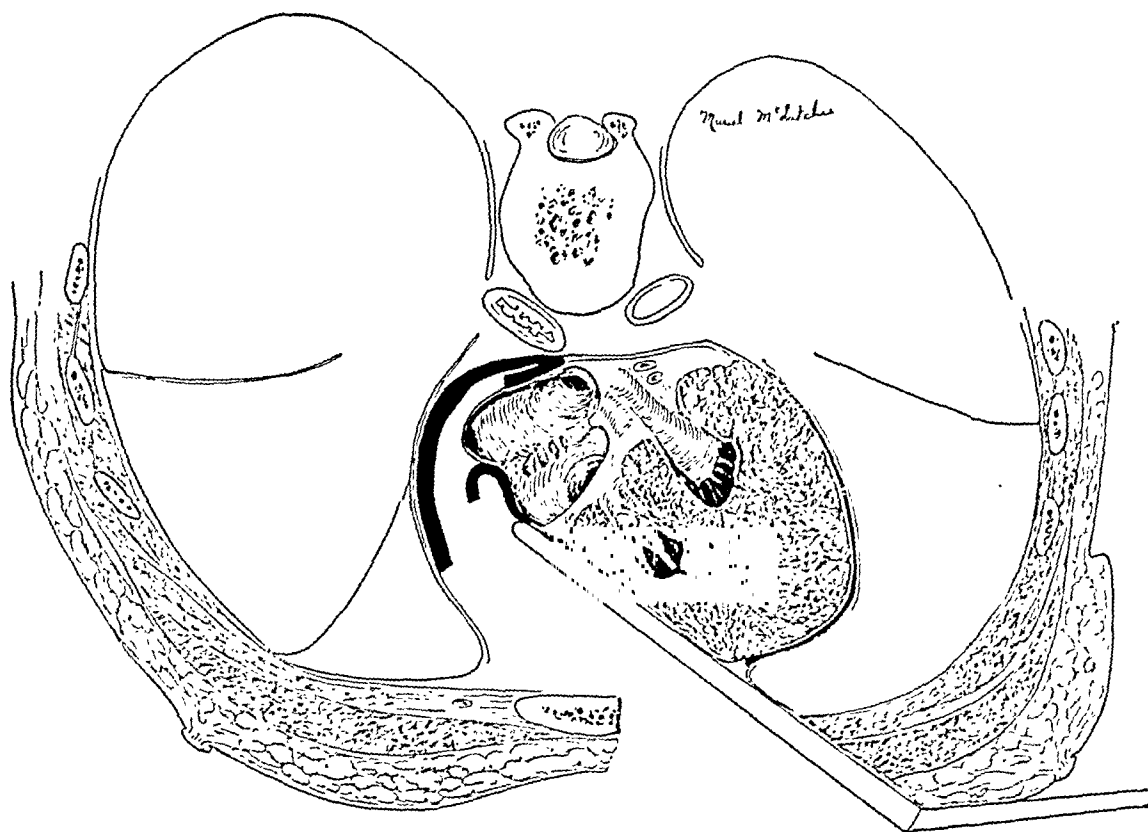


FIG. 5.—Decortication of right auricle. Parietal pericardium resection unimportant in this area.

accepted as correct, his conclusions appear unwarranted. The experiments with a catheter in the pericardium demonstrating a rise in venous pressure and a reduction in cardiac output following the injection of air are perfectly understandable and were recorded by Cohnheim⁶ years ago.

The pressure relations in the experiments with the animal in a negative pressure chamber appear to be confused by the fact that the manometer registering changes in the venous pressure was placed *outside* of the chamber. To prove satisfactorily the point at issue the changes in venous pressure should be recorded on a manometer *within* the negative pressure chamber or cardiac output changes be demonstrated as taking place under these conditions. Such data are not on record.

Subatmospheric pressure applied over the heart and at the same time over

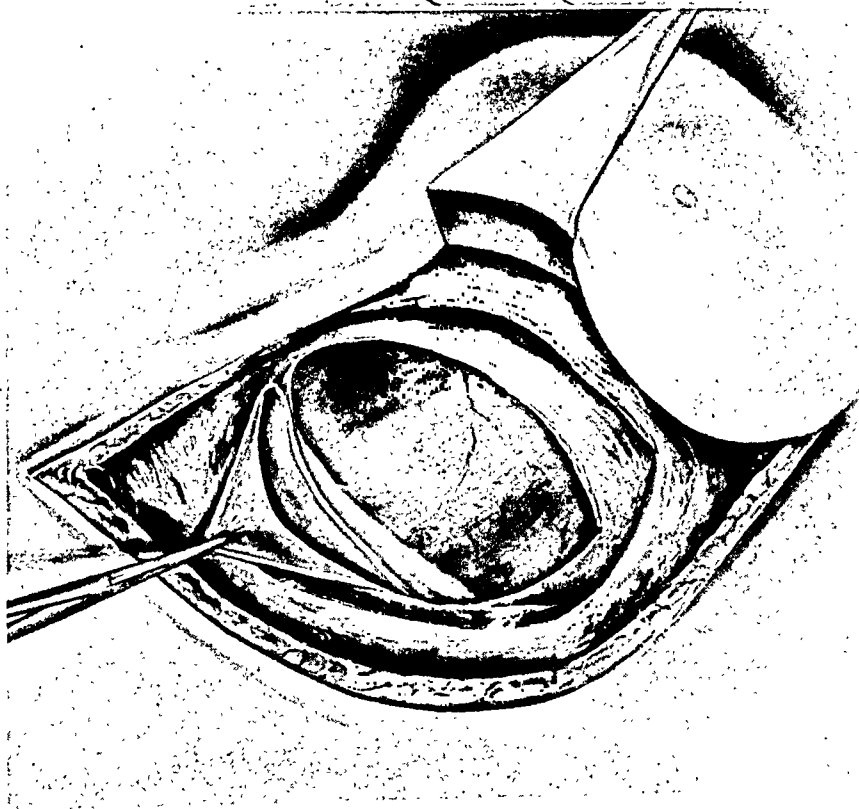


FIG. 6.—Operative sketch showing opening of cavity containing fluid.

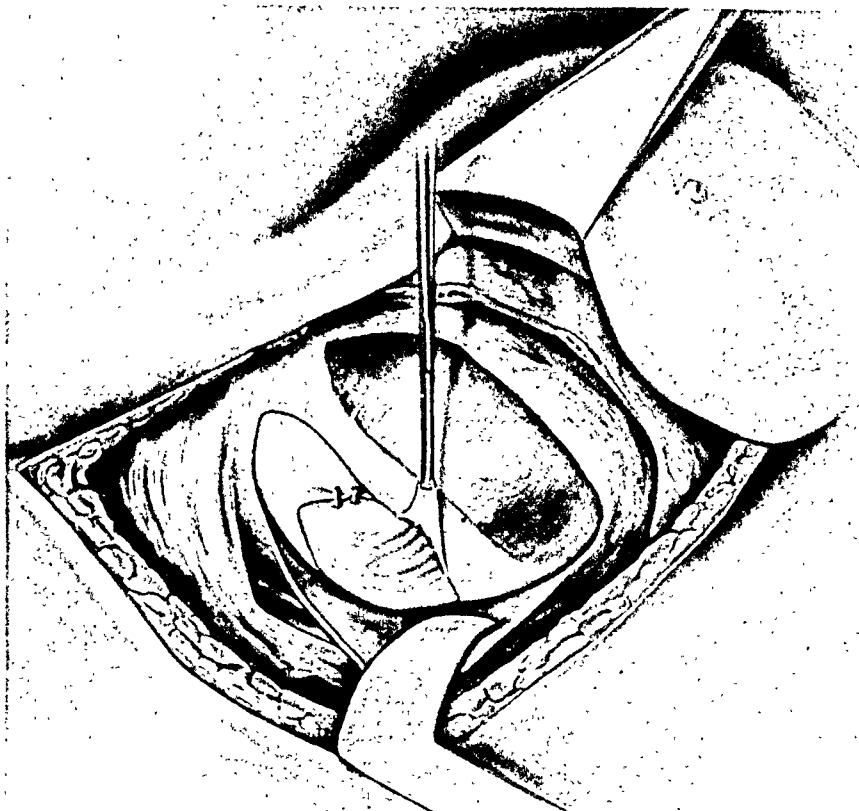


FIG. 7.—Dealing with densely adherent area by approach from both sides. Bleeding area controlled with stitches.

the surface of the body (with the exception of the head) is not to be confused with the differential pressure employed in pulmonary surgery. It is difficult to see how differential pressure can be applied to the heart in relation to the rest of the body except by the limited experimental method of a catheter in the pericardium.* If the major portion of the body as well as the heart is exposed to a subatmospheric pressure there is no ground for postulating any force effecting a change in the venous return. Even if the head is kept at atmospheric pressure the theoretical change would be slight as the cerebral circulation is protected by the rigid skull.

These discrepancies are cited to emphasize a diametrically opposite viewpoint regarding the circulation during and immediately after the operation. While Beck focuses his attention upon failure of the peripheral circulation from a *reduced* filling of the heart, I consider the real hazard of the operation to lie in exposing the weakened musculature of the heart after it has been released from the scar to *too great* a venous return. From this point of view the effect of atmospheric pressure on the surface of the heart would be welcomed. I have deliberately attempted to reduce the venous return to the heart during and immediately following the operation. Patients are operated upon in a sitting position under general anesthesia and kept upright during their convalescence. When a small pneumathorax has been accidentally induced at the operation it has deliberately been allowed to remain providing respiratory reserve was adequate. A pneumathorax tends to reduce further the effective venous pressure during the immediate postoperative period.

It must be clearly kept in mind, however, that a reduction in the effective venous pressure may be dangerous if the heart is not relieved of its constricting scar. The high venous pressure in constrictive pericarditis as in other forms of cardiac tamponade appears to aid the heart to maintain an output compatible with life. If this high venous pressure, which in one sense may be considered a compensatory phenomenon, be lowered by loss of blood or by the anesthetic while a high degree of tamponade still exists, the resulting fall in cardiac output may be of serious import. In the cases of active tuberculous pericarditis referred to above, circulatory failure, *i.e.*, inadequate left ventricular output started with the administration of the anesthetic, progressed with the loss of blood during the chest wall dissection, and owing to the fact that the heart could not be liberated, terminated in death. An increment of pneumacardiac tamponade would, it is true, have been a further insult to the circulation under these conditions, but its importance is difficult to evaluate and means to obviate its effect are not at hand.

It may be emphasized again, that the patient will withstand the operation well if the heart is liberated and its muscle is competent. Failing this,

* Sauerbruch's first differential pressure apparatus for animal experiments was designed to do this as it enclosed just the thorax. In his early work with the differential pressure chamber for human subjects the lower extremities of the patient were enclosed in a bag and connected to atmospheric pressure to avoid "venous stasis." This was soon discarded as unimportant. (See Tait: Surg., Gynec., and Obst., 4, 59, 1907.)



FIG. 8.—Ascites of six and one-half years' duration due to constrictive pericarditis. Unaffected by Talma omentopexy.



FIG. 9.—Complete cure of patient shown in Figure 8 by pericardial resection.

CHRONIC CONSTRICTIVE PERICARDITIS

blood loss or other elements reducing the effective venous pressure may be poorly tolerated.

TABLE I
CHRONIC CONSTRICTIVE PERICARDITIS

Patient	Age	Sex	Date of Operation	Result
1. C. S.	18	F.	7 18 28	Cured
2. J. N.	16	M.	9 27 32	75% improvement. Sedentary work. Persistent ascites
			11 16 33	
3. L. F.	30	F.	4 6 33	Cured
4. C. F.	19	M.	4 22 33	Cured
5. L. C.	12	M.	7 12 33	Cured
6. B. K.	12	F.	11 16 33	Cured
7. D. G.	11	F.	2 27 35	Cured
8. G. P.	43	M.	10 18 35	Improvement. Sedentary work
9. I. B.	47	M.	11 6 35	75% improvement. Light physical work
10. J. H.	52	M.	9 30 33	Died 5th day. Pulmonary edema. Cholelithiasis and advanced portal cirrhosis of liver (not of usual cardiac cirrhous type)
ACTIVE TUBERCULOUS PERICARDITIS				
11. J. M.	36	M.	4 2 34	Died at operation
12. J. B.	23	M.	1 14 31	Died 12 hrs. postoperatively

RESULTS.—The results are indicated in Table I. By "cured" is indicated normal functional activity for patient's age and sex. In boys this means participation in athletics such as football and track. Complete absence of ascites and edema is also recorded in the cured cases (Figs. 8 and 9). In some instances an abnormal prominence of the neck veins and a moderate enlargement of the liver, the latter due to permanent connective tissue changes, are residual legacies of the disease.

The patients classified as improved show some functional impairment. In one instance this is persistent ascites that has not been relieved by a second and more extended pericardial resection. Functional capacity is greatly improved in this case. The other two cases are still showing improvement of functional capacity and have already been greatly helped by the operation.

Case 10 proved on autopsy to have had an advanced hepatic cirrhosis of the portal type. Portal cirrhosis is not known to be associated with the Pick syndrome and it seems probable that at least part of the preoperative symptomatology may have been associated with this lesion. This patient had a completely calcified pericardium.

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Idem: *Am. Jour. Phys.*, 93, No. 2, June, 1930.
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- ⁶ Cohnheim, Julius: *Lectures on General Pathology*, 1, New Sydenham Society, London, 1889.

DISCUSSION.—DR. ALFRED BLALOCK (Nashville, Tenn.).—I agree with Doctor Churchill as to the undesirability of operating upon a patient with an acute pericarditis due to tuberculosis. However, occasionally we have found it necessary to do this, because otherwise the compression of the heart would have killed the patient before the chronic stage was reached.

We have at the present time in the Vanderbilt Hospital a patient who was operated upon about a year ago, whose disease was tuberculous in origin, who improved for several months, then became worse again. A second operation was performed a couple of months ago, and the patient is now better but still not cured.

One of the most interesting points connected with the treatment of all patients with constrictive pericarditis has to do with the time at which the operation should be performed, and I cannot answer the question. If one operates during the acute stage, the operation is easier from a technical standpoint, but the patient is more apt to die of the infection. If one operates during the chronic stage the heart muscle is thinned, is atrophic in many areas, and the operative procedure itself is associated with more danger.

Table I shows the findings in ten patients studied at the Vanderbilt Hospital. These patients were observed by Doctors Burwell, Bigger and myself. It brings out some rather striking points in connection with a statement made by Doctor Churchill, namely, that the diagnosis is not difficult, and it is surprising that more cases have not been discovered.

All ten of these patients had distended veins, increased venous pressure, enlarged liver, edema (peripheral), tachycardia, diminished pulsation on fluoroscopic examination and fixation of the heart. Nine of the ten had a paradoxical pulse, low pulse pressure, and faint heart sounds. Eight of the ten had ascites and pleural effusion.

TABLE I

SYMPTOMS AND SIGNS IN TEN CASES OF CONSTRICTIVE PERICARDITIS

	Per Cent
Distended veins.....	100
Increased venous pressure (195–390 Mm. H ₂ O).....	100
Enlarged liver.....	100
Edema (peripheral).....	100
Tachycardia.....	100
Diminished pulsation (fluoroscope).....	100
Fixation of heart.....	100
Paradoxical pulse.....	90
Low pulse pressure.....	90
Faint heart sounds.....	90
Ascites (often early).....	80
Pleural effusion.....	80
Greatly enlarged heart.....	0
Pulmonary edema (gross).....	0
Hypertension.....	0
Valvular disease.....	0
Systolic retractions.....	0
Auricular fibrillation.....	0
Paroxysmal dyspnea.....	10

The other findings were not encountered frequently. For example, none of them had an enlarged heart, pulmonary edema, hypertension, valvular disease, systolic retractions or auricular fibrillation. The disease was tuberculous in origin in seven of these cases, and pyogenic in the others. Eight were operated upon. Three are now able to do a full day's work, two are improved, and three are dead. One of the latter three was improved for six months and then died of miliary tuberculosis.

DR. EDWARD D. CHURCHILL (Boston, Mass.) closing.—In regard to the recognition of the active phase of tuberculosis of the pericardium, I can add little more to the statement that finding tubercle bacilli in the aspirated fluid is the only certain criterion.

I have purposely specified the active phase of tuberculous pericarditis, because we do not know the nature of the original pericarditis, in many of the so called chronic constrictive cases. It is believed that many of them are healed tuberculosis, but examination of the scar shows no evidence of tuberculosis.

TUMORS OF THE CHEST WALL

KELLOGG SPEED, M.D.

CHICAGO, ILL.

THIS type of new growth is limited to tumors taking origin in the chest wall or the layers of the wall, excluding superficial tumors of the external surface, such as lipomata and superficial cysts of the skin or its appendages as well as all primary tumors of the breast. The proportion of chest wall tumors to tumors of the body as a whole is small. Their frequency may lead to inaccurate diagnosis and prognosis, while their size and situation lend unusual interest. A study of their individual course may necessitate years of observation and their surgical removal may involve both thoracic and abdominal cavities as well as the vital structures contained within them.

Collections of the reports of these tumors have been made by Hedblom,^{11, 12} Heuer^{13, 14} and others, and now that over 300 instances have been cited in surgical literature, no attempt is made to review the group numerically. The study of the collection of tumors in the Registry of Thoracic Tumors will eventually lead to authoritative statistics easily tabulated for reference. It is my purpose to cite personal experiences with some patients followed for several years.

In 1921, Hedblom¹² collected 213 instances of chest wall tumor; not all primary, however. Of this collection, 167 were tumors of the ribs (78.7 per cent) of which 62.8 per cent were sarcomata and 19 per cent were chondromata. Out of the total number, 46 were tumors of the sternum, of which 54.3 per cent were sarcomata and 13 per cent were chondromata. A later report by him¹¹ (1933), which covered a collection of 313 case histories, gave 22 personally handled instances to be added to the collection of 78 reported in 1921, and showed that 12 were metastatic tumors which could not be included in the primary group. Their study, however, proved of great value in establishing differential diagnosis, establishment of their identity as secondary tumors being difficult. Of this group, 261 (81 per cent) were tumors of or about the ribs, and 52 (20 per cent) were tumors of the sternum. Of the 70 instances of the rib tumor, 50 were sarcomata and 10 chondromata.

Tumors on the right side of the chest predominate. A history of trauma was obtained in about 20 per cent of the cases and may be an etiologic factor. A favorite tumor site is the anterolateral chest wall. Males predominate (60 per cent), and the ages of patients vary from a few months to 80 years.

Many pathologic types are found among the primary tumors, most of the secondary tumors being carcinomata, metastatic from bronchogenic, adrenal, thyroid or mammary cancer. One classification of primary tumor of the chest wall, advanced by Zininger,³⁰ is as follows:

(A) Tumors arising from the deep structures of the thoracic wall partly intrathoracic.

(B) Tumors arising from more superficial structures of the thoracic wall, but apparently fixed to deeper structures.

(C) Tumors arising within the thorax presenting through the thoracic wall.

Subcutaneous fibroma and lipoma and small symptomless chondroma of the ribs, found at physical examination, are not included in this classification. This, I believe, is unfortunate because several instances of malignant tumor, among the reported cases, were traced to very humble origin as small chondromata observed over a period of years, finally becoming malignant. Zininger reported seven cases from the Peiping Union Medical College Hospital, one case from another Peiping hospital and five cases of superficial tumor and three of intrathoracic tumor presenting through the thoracic wall. These were divided into the following:

Group A.—Eight cases, three radically resected. One died, one recurred four months after resection. The results were not known in three, two presented no change after operation, one was well one year later.

Group B.—Five cases, three operated upon. All apparently cured.

Group C.—Three cases. None operated upon.

Lipomata and hemangiomata of the chest wall may lead to great difficulty in diagnosis and treatment and must be considered in any classification, although they may be quite benign. A large subpectoral lipoma, of 14 years' duration, weighing 3.8 kilos, was removed by Vielle and Eysseric²⁰ from a man 70 years old. There was no recurrence after removal. Thoracic lipomata have been classified by Heuer as follows:

(1) Hourglass or dumb-bell type.

(2) Anterosuperior mediastinal lipoma presenting at the root of the neck.

(3) Intrathoracic lipoma.

I have recorded an instance of Class 2 which became malignant and inoperable. Case 6 of this report may be of the first type, but no biopsy was performed.

Hemangiomata of the chest wall have been reported by Sorrel,²⁰ Adams,¹ Lyle²⁰ and others. Sorrel's patient was a boy, aged ten, whose left chest bulged as if from an intrathoracic tumor extending through the ribs, but both roentgenologic and physical examination failed to give satisfactory information. The mother said that the child had been operated upon soon after birth for a tumor in the chest and there were scars found over the fourth and fifth interspaces with an angiomatous spot near there several centimeters square. The whole chest wall appeared thickened and edematous, without axillary adenopathy. There was some evident increase in the collateral venous circulation seen externally on the thoracic wall. This child received no treatment, although various injections and roentgen therapy were suggested.

Adams' case was a girl, aged five, who had a large tumor on the right chest at birth, when she weighed six pounds and 11 ounces. This had been aspirated and when seen at the later age was an hemangiomatous mass, sessile, lobulated and tense, situated at the right midaxillary line. The mass finally broke

down and ulcerated, after which the patient developed a fever and the growth slowly disappeared, possibly as a result of infection and thrombosis. No operation was performed.

Lyle's case was a woman, aged 77, who presented a swelling in the right, second intercostal space close to the sternum. It enlarged when she bent forward. Operation disclosed a shirt stud hemangioma with expansion between the pectoralis major and intercostal muscles. It was excised en masse. The stem of the collar button mass was composed of a dilated varix, the deeper portion communicating with vessels of the thoracic cavity.

One instance of cystic hygroma of the chest has been recorded by Ingram¹⁵ in a female child, six weeks old, who at birth had a lump the size of a hen's egg in the right chest. This was round and seemed to be free in the subcutaneous tissues. It was removed surgically and found to be a thick walled cyst, with a few small cysts. There was no evidence of malignancy.

The case I reported in 1930 was a malignant desmoid tumor and is included as Case 1 in this report. Cystic lymphangioma of the chest wall has been recorded.

Most thoracic tumors are chondrosarcomata or fibrosarcomata and many undergo myxomatous degeneration. They grow by close infiltration; they metastasize often late and are practically all potentially malignant, even if a microscopic section of a small tumor in an early stage appears benign.

The symptoms are tumor mass, pain, loss of weight, cough, dyspnea, cyanosis, pleurisy and changes incidental to metastases involving the spinal cord or other structures. There may be pleural exudate.

The diagnosis may be evident at sight, especially if the mass has been present for years. The chondromata and fibrosarcomata tend to be fixed to adjacent rib and cartilage and rather steady in growth. Their surface may be nodular and hard. The source of the tumor may be difficult to ascertain, as a flat roentgenogram of the chest may show no changes in rib or sternum, no new bone formation, but a denser shadow than normal for lung and pleura, if the thoracic cage has been invaded. Metastases to the lungs come very late, but a shadow of advancing tumor may be seen beneath the chest wall in lateral or oblique film. Where pleural exudate is present, the roentgenologic findings may be very obscure and misleading as the fluid masks all other shadows. Key¹⁶ said in 1921: "Even in the case of large tumors of the chest wall, the induction of artificial pneumothorax with subsequent x-ray examination and thoracoscopic examination may be of great value for a more accurate diagnosis and for the determination of the extent of the tumor. By such a procedure valuable information may be obtained, which successfully completes the x-ray examination made previous to the induction of pneumothorax."

This advice should be followed in every case where the full extent of the tumor cannot be determined and may be supplemented by the use of the thoracoscope to determine the presence of adhesions between the pleural surfaces, metastases on them or for the purpose of biopsy of material within the

thoracic wall. Very small tumors between the ribs may be palpated in physical examination and discovered, although there may be no pain or complaint. In the face of uncertainty, an exploratory incision, a thoracotomy and biopsy are indicated, as there is no doubt, if one reviews the histories of the reported cases, that any tumor of the chest wall should be radically excised during its early stage. Pneumoperitoneum is also a great help in differentiating intra-abdominal lesions or extensions, particularly those involving the liver, diaphragm or subdiaphragmatic spaces.

Differential diagnosis must include tuberculosis and syphilis of the ribs, old fracture of the ribs, nonspecific necrosis of any part of the bones of the thorax, dermoid cyst, abscess, aneurysm, multiple myeloma and the great difference between resectable primary and nonresectable secondary tumor. The physical examination must be thorough and should attempt elimination of a primary tumor, and also include roentgenograms, not only of the chest, but also of pelvis, skull and other suspected bones.

Many primary tumors are removable, but demand a well planned, bold attack with suitable preparation of the patient after a searching diagnosis for the extent of the growth. Many of the lateral wall tumors involve the pleura and diaphragm. In the series reported by Lund, six cases involved injury to the diaphragm; all recovered. Lockwood,¹⁰ Speed and others have reported such cases. Hedblom collected a series which contained 12 extensions to the diaphragm, showing an incidence of secondary tumor of the diaphragm in 14 per cent of malignant chest wall tumors. Secondary tumors of the diaphragm from any other cause will rarely be of surgical importance as operation would be useless. The pericardium and sternum are often involved. Primary tumors of the sternum, while rare, may be found or palliative operations for secondary tumors of the sternum may be indicated, as recorded by Graham and George W. Crile, Jr.⁶ Pulsating tumor of the sternum is generally metastatic. Out of the total of 18 cases collected from the literature by Crile, nine were metastatic from hypernephroma and the same number came from malignant adenoma of the thyroid. Tumors may arise at the costo-vertebral junction or may be confused with an active syphilitic infection, as in instances recorded by Heuer.

The dangers of opening the thorax are real at any operation for the removal of the chest wall tumor. A graded operation may be indicated to avoid lung or mediastinal collapse. Hemorrhage may get beyond control and no operation should lead to such abnormal mobility of the chest wall that cardiac and respiratory embarrassment follow. Many operations are followed by recurrences of chondro- or fibrosarcomata, partly because of incomplete local excision, so difficult are the technical problems of removal. The chest wall and diaphragm must be approximated and phrenicotomy may be required either before or after operation to permit apposition of these tissues when partially resected. In some cases, a secondary operation to strengthen the chest wall may be required. Harrington has suggested using the scapula to help cover an opening if the defect is large and posterior.

From the Chest Tumor Registry, Andrus reviewed 155 new growths, 117 of which were well diagnosed; 38 were of unproven diagnosis. Of the chest wall tumors, sarcoma predominated. The literature leads me to believe that chondro- or myxochondrosarcomata dominate in number, but only four out of 16 chest wall tumors in the Registry are so classified, ten being fibro- or osteogenic tumors. There were six males and four females and ages varied from 12 to 60 years. Previous trauma was mentioned in but two of the 16 reports. The results of 12 operations listed in the Registry were: one death from shock in five hours, seven recurrences or metastases in from three months to three and one-half years, and four free from recurrences one to five years after operation. My patient, with a malignant desmoid, still lives, 12 years after operation.

In a search of the literature, I can find but one other instance of cranial metastasis similar to that shown in Case 5, who also had a metastasis in the left thigh, both being outside of bone. In February, 1928, Polloson and Novel²⁵ recorded an instance in a male, aged 25, with a painful tumor just below the right breast. There was a family history of tuberculosis. His tumor was hard, smooth, attached to ribs, extending from the axillary lymph nodes. Roentgenography showed a quadrilaterally shaped tumor centered at the fifth rib. A puncture was negative. The tumor was removed by operation and proven to be sarcoma. On August 20, 1930, the patient reported showing a metastatic mass in the left frontal and two rounded masses in the occipital region looking like sebaceous cysts, but of very rapid growth. They were accompanied by headache, and roentgenologic examination showed loss of cranial substance at the areas mentioned.

Metastases from malignant osteogenic and chondromatous tumors into the skin, where they form either new bone or cartilage, are most unusual. Case 5 becomes of interest on this account alone.

CASE REPORTS

Case 1.—Female, aged 35, married, one child, first seen in April, 1924. In 1912, she had jumped from a street car and in addition to a possible skull fracture had sustained some injury of the right chest, but there were no known fractures of the ribs. In 1917, a tumor mass had appeared on the anterolateral aspect of the right chest wall over the lower ribs and their cartilages. This grew for five years, reaching the size of a child's head, when an attempt was made by a surgeon to remove it through an incision in the right rectus region extending up onto the thoracic wall. It was impossible to obtain from the hospital where this operation was performed any record of the extent of the surgical intervention or the pathologic examination of the tumor.

Examination by me in April, 1924, showed a well nourished woman presenting a tumor the size of a grapefruit on the anterolateral wall of the right chest attached to the lower ribs (Fig. 1). The tumor was rounded, solid, had a consistency of cartilage and extended over the area from the sixth to the tenth rib, inclusive (Fig. 2). The scar of the previous operation, seven inches long, lay median to the main tumor mass extending downward in the right rectus region from the costal margin. Routine laboratory examinations of the patient were normal. The roentgenologic examination showed no apparent pathologic changes in the ribs or other bones. The left side of the chest

TUMORS OF THE CHEST WALL

showed slightly denser than the right, but there were no evidences of metastases in the lungs. The right diaphragm appeared bulged upward.

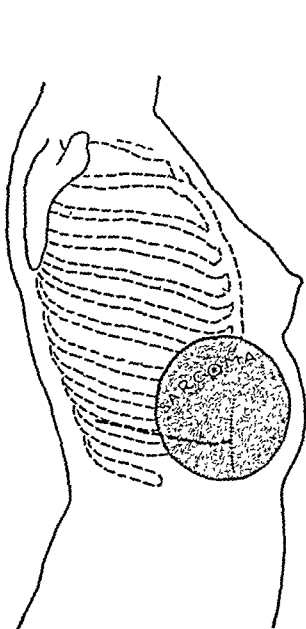


FIG. 1.—Schematic drawing representing the position of the tumor mass on the lateral anterothoracic wall of Case 1. The interrupted line represents the incision at operation. (Surgical Clinics of North America, W. B. Saunders Company.)

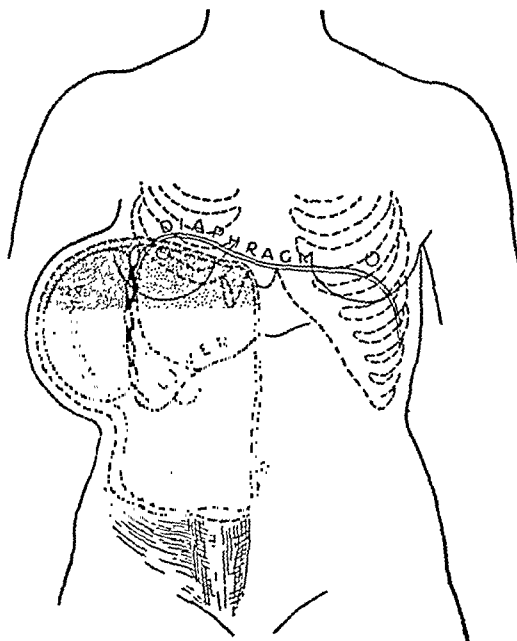


FIG. 2.—Schematic drawing of the position of the tumor mass of Case 1, illustrating its infiltration around the sixth to tenth rib into the liver and diaphragm. The stippled area of the abdominal wall represents the amount of muscular and fascial tissue which had to be removed with the tumor. (Surgical Clinics of North America, W. B. Saunders Company.)



FIG. 3.—Removed tumor of the thoracic wall split open through the central rib enclosed in the mass. Liver substance lies centrally and the thoracic wall in the outer surface of the specimen. At the bottom is some of the infiltrated diaphragm. (Surgical Clinics of North America, W. B. Saunders Company.)

Operation April 28, 1924. Through a transverse incision 12 inches long at the right costal margin extending from the midline laterally and outward, a dissection of the skin away from the tumor mass was performed. To obtain the tumor intact, it was found

necessary to remove all muscular layers of the right abdominal wall down to the iliac crest and backward to the posterior axillary line, including part of the right rectus muscle and the mass of the right lower ribs and their costal cartilages. Both the right pleural and peritoneal cavities were widely opened. No adhesions were found in the right pleural cavity between lung, pleura and diaphragm. The right lung retracted and occupied about half the space of the right side of the chest. To lift the tumor away, it was found necessary to resect the anterior and lateral insertion of the diaphragm for at least ten inches, and in the abdominal cavity the resection was carried through adherent

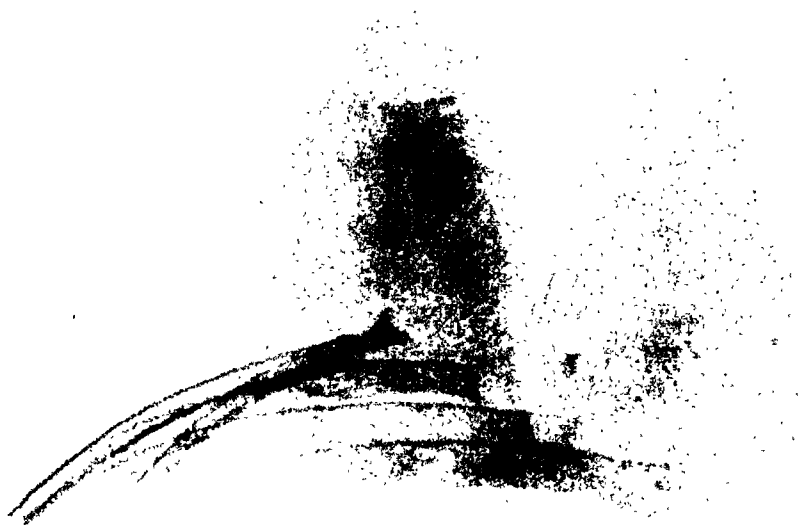


FIG. 4.—Roentgenologic view taken laterally through the removed specimen of Case 1, showing five ribs, tumor and part of the liver. The main mass has been split to obtain blocks for histologic study. There are no noticeable changes in the osseous structures of the ribs which have been surrounded but not invaded by the new growth of the tumor. The density of the hard fibrous-like tumor is not so great as bone. Desmoid. (Surgical Clinics of North America, W. B. Saunders Company.)

omentum, gastrohepatic ligament and the anterolateral surface of the right lobe of the liver. The liver was resected with the electric cautery, bleeding being controlled by deep mattress sutures of catgut (Figs. 3 and 4). A narrow gauze pack was inserted down to the cut liver surface and the free, retracted edge of the right diaphragm was sutured to the remnants of the transversalis fascia and the sheath of the rectus by pulling the diaphragm well down over the dome and anterior surface of the liver. To close the pleural cavity, the subcutaneous tissue of the chest skin flap was sutured to the diaphragm. The skin was then closed over the abdominal cavity with no peritoneum or muscular tissue remaining beneath. A tubular drain was inserted laterally in addition to the gauze drain extending from the liver surface.

The shrunken gross specimen after hardening was $12 \times 10 \times 8.6$ cm. It included portions of the sixth to the tenth rib, inclusive, the deeper layers of the abdominal wall adjacent to the peritoneum, liver and diaphragm. Histologic examination by Dr. E. R. LeCount gave a diagnosis of desmoid tumor (fibrosarcoma). There were fibroblasts, fibrous tissue, veins with no apparent walls and arteries with no muscular fibers in their walls. There was no direct invasion of adjacent structures by the tumor, but a simple pushing aside or compression with adherence by expansile growth.

The patient recovered without incident or unhappy complications, except for a persistent hernia in the site of the tissue removed. The diaphragm later was studied

roentgenologically and found to regain normal muscle tone and apparent strength, holding its attachment to fascia and the remaining chest wall, not deforming and apparently enervated normally.

The patient has borne four children since this operation. Late in 1935, she underwent an hysterectomy.

Examination March, 1936, 12 years after resection of this desmoid tumor, her age now being 47, shows that her weight is 210 pounds. She appears robust, does all her own housework and runs a small store. General physical examination reveals nothing more than the scars of operation, a recent suprapubic midline scar following hysterectomy and the two long, crossing scars, now white, following resection of the chest and abdominal wall 12 years ago. The ribs are lacking up to the sixth on the right side from the sternum to the midaxillary line. There is a large bulging herniation in the right abdominal and chest area on coughing, but no pain or bowel disturbance and no evidence of tumor recurrence. The liver is not distinctly palpable, although the skin wall over it is thin. Her only complaint is against wearing a corset belt to control the lateral abdominal bulging (Figs. 5 and 6). (This case was listed with the Registry of Thoracic Tumors and reported in *Surgical Clinics of North America* 10, 213, April, 1930.)

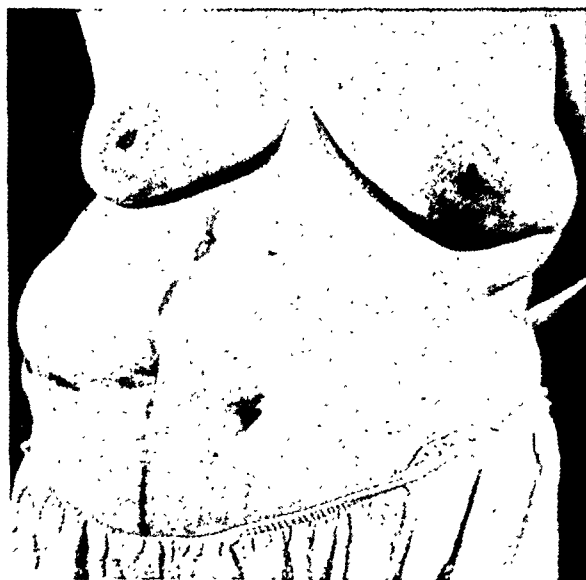


FIG. 5.—Photograph of abdominothoracic wall and hernia of Case 1, 12 years after removal of tumor.



FIG. 6.—Lateral view of abdominothoracic wall showing extent of scar and hernia.

Case 2.—Female, aged 34, married eight years and has borne three children. In February, 1930, she presented a tumor in the right axillary region of two years' duration with rapid enlargement in the two months before coming to the hospital. The mass had never been painful or tender, there was nothing wrong with the right breast and there was no history of trauma. The general physical and laboratory findings were normal, except for the presence of a firm mass the size of a grapefruit in the right axillary region. This was not reddened nor did it feel hot and it was quite well demarcated, seemingly adherent to the deep fascia and muscles. Roentgenologic examination showed no apparent pathology in the upper half of the right humerus, the chest or pelvis. An exploratory puncture obtained a small amount of thick mucoid fluid tinged with blood and a diagnosis of axillary cyst was made. The tumor was removed February 17, 1930, and the wound healed kindly. The patient left the hospital March 8, 1930.

The specimen consisted of a mass $18 \times 9 \times 6$ cm., attached to an adherent piece of skin 6×4 cm. The portion adjacent to the skin was composed of a colloidal-like substance with evidence of old and new hemorrhage into it along with extensive regressive changes. The cut surface of the main tumor was gray-white and homogeneous, showing on microscopic section fibrosarcoma invading the chest wall muscles.

The patient appeared a second time October 24, 1930, complaining of swelling in the right axillary region for the previous three months with considerable pain for two weeks. She had lost four pounds in weight. Examination at this time showed a mass about the shape and size of a human breast. There was some reddening of the central portion and in the middle was a small area of ulceration, less than one centimeter in diameter, which oozed a little blood (Figs. 7 and 8). This mass was quite hard, fixed to underlying ribs and extended up into the axilla, in which there was no adenopathy.

Roentgenologic examination placed this tumor in the soft parts of the chest wall and no rib or bony involvement was found. In the superior mediastinal area there was an abnormal shadow, which the roentgenologist considered to be a substernal thyroid. It was probably a metastasis of the chest wall tumor.



FIG. 7.

FIG. 8.

FIG. 9.

FIG. 7.—Posterior view, just before operation, of Case 2, showing tumor mass, necrotic center area and pendulous breast below.

FIG. 8.—Lateral view of Case 2, just before operation.

FIG. 9.—Lateral view of Case 2, six months after operation for removal of tumor. The breast has been swung up to cover the defect. Full abduction of the arm is possible.

On November 6, 1930, the tumor mass was removed, together with portions of four underlying ribs, without opening the pleura. To cover the rather large defect in the chest wall, the pendulous right breast was undermined and swung up into the axillary space. This fitted well and permitted wound approximation without undue tension. A second histologic diagnosis confirmed the first, made elsewhere, of fibrosarcoma with marked myxomatous regressive changes.

The wound healed normally (Fig. 9). The patient died one year after operation, from metastases apparently in the mediastinum and lungs.

Case 3.—Male, aged 30, single, first seen in April, 1930. Four months previously, after a sudden jerk of the left arm, he noticed a swelling and some persistent pain over the left upper ribs. The tumor mass, which had developed over the upper left ribs, increased in size, became more painful and he also noticed pain in the right knee. In the four months he had lost five pounds in weight. There was no cough, dyspnea, cyanosis, expectoration or hemoptysis.

Examination showed the chest wall developed; no enlargement of the thyroid. The lungs were normal to percussion and there were no râles. The heart was enlarged. Over the left first rib was a mass the size of an orange, firmly adherent. There were some enlarged left axillary lymph nodes. A diagnosis of malignant tumor of the chest wall, with metastases in the left axilla and right knee, was made. A biopsy on the

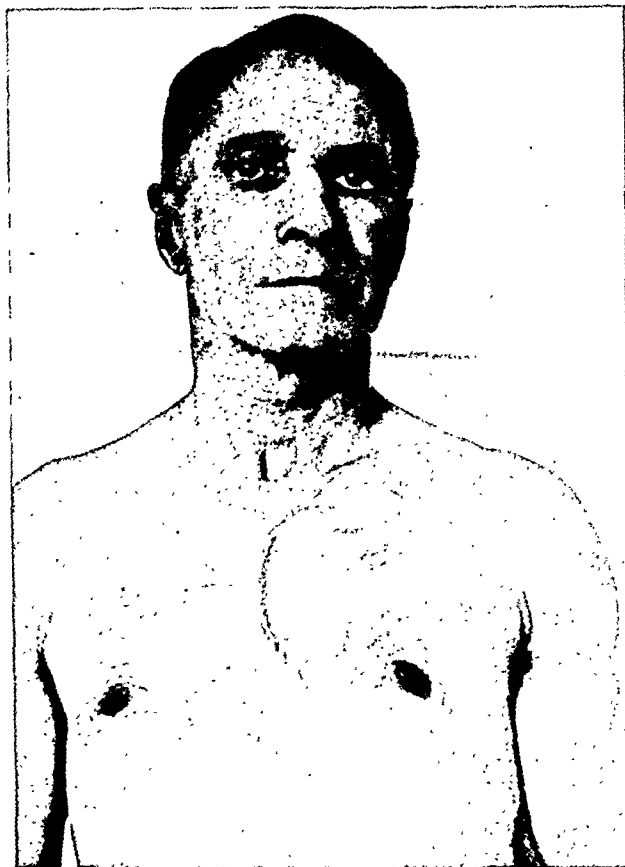


FIG. 10.—Anterior view of tumor of Case 4.



FIG. 11.—Lateral view of tumor of Case 4.

tumor was performed. The patient explained that his first physician had likewise performed a biopsy and told him he had a sarcoma. Roentgenologic examination May 15, 1930, revealed destruction of the anterior portion of the left first rib, but whether this was the site of origin of the tumor could not be definitely stated. On May 31, 1930, a second roentgenologic examination revealed a questionable destructive or lytic process involving the internal condyle of the right femur. No decision was reached as to the character of this osseous change because his knee pain was located over the external condyle of the femur.

Operation for radical excision could not be performed on the chest, because the site of the biopsy had become acutely infected. An histologic diagnosis of anaplastic columnar cell carcinoma was made, but it could not be decided that this was bronchogenic in character. The infection in the tumor continued until June 21, 1930, when the patient left the hospital to go to his home in Porto Rico, no definite diagnosis having been established.

This case illustrates the difficulties of diagnosis between primary and secondary tumor, even after biopsy is performed. Additional examination, including bronchoscopy, or lung collapse, might have determined the source of this tumor.

Case 4.—Male, aged 62, was admitted to the hospital March 31, 1930, complaining of a tumor mass on the left chest wall of three years' duration. When first noticed, this was the size of a pea at the level of the third intercostal space, firm, not tender, gradually increasing until it reached the size of an orange. About six months before he was examined, the mass took on rapid growth and doubled in size until it reached its maximum (Figs. 10 and 11). There was no discomfort or pain.

A general physical examination revealed little abnormal. He was edentulous, but well nourished. There were no lymph nodes in the neck or axilla. Roentgenologic examination showed the main mass of this tumor to be faintly radio opaque; it appeared to be situated mostly on the anterior side of the upper ribs, which were not grossly deformed. A small bulging shadow was also seen in the anterior mediastinum and beneath the clavicle fused with shadow of a sclerotic aortic arch. No metastases were seen in the lungs. The tumor mass was very firm, lobulated, fixed to the chest tissues, encroached on the sternum and extended above the clavicle. A clinical diagnosis of chondrosarcoma was made.

Operation March 13, 1930. A transverse incision over the tumor mass permitted retraction of part of the pectoralis major muscle, the fibers of which were split and the tumor exposed down to its attachment to the second, third and fourth ribs. In attempting to free the tumor, its major portion broke away. The smaller, remaining portion was removed with portions of the attached ribs and costochondral junction clear to the sternum. This excision broke into the pleural cavity and the collapsed left lung was seen. Bleeding points were controlled and the skin was closed tightly over the defect. There was a slight rise in temperature, lasting but two days, followed by a small amount of fluid in the left thoracic cavity and a smooth postoperative recovery, with a discharge of the patient from the hospital March 28, 1930.

The specimen consisted of two tumor masses with attached muscles, one $15 \times 9 \times 7$ cm. and the other $8 \times 7 \times 3$ cm. The larger mass was moderately firm but felt cystic. On gross section it was found to be composed of cyst-like spaces with cartilaginous walls. The cystic areas were filled with glairy mucoid substance and amorphous yellow fibrous-like material. The smaller tumor, with attached ribs, was firmer and more homogeneous. A frozen section revealed a chondromatous structure, but no malignancy could be identified. The paraffin section showed chondrosarcoma with myxomatous degeneration.

He was reported to be alive six months later, but suffering from pulmonary complications and local recurrence. There was free fluid in the chest cavity. No further trace of him has been obtained. The histologic diagnosis was chondrosarcoma.

Case 5.—Male, colored, aged 40, single. Admitted to hospital in August, 1930, complaining of a tumor mass on the right side of his chest (Figs. 12 and 13), which was of five years' duration. The condition apparently originated as a nodule at about the level of the right third rib not far from the sternum. Within a year the mass had reached the size of an orange and was hard and fixed to the chest wall. In 1927, biopsy was performed and he was told the tumor was a fibrosarcoma, its removal advised and operation performed elsewhere. Within one year it had recurred, grown to its size before removal and continued to increase in spite of all treatment.

When first examined in 1930, there was pain in the chest, no cough, no dyspnea, he was doing manual labor and was chiefly distressed on account of the size of the mass. He was able, at that time, to rest his chin on the bulging tumor. The mass was the size of a small melon, felt tensely cystic in some areas and was definitely nodular but did not pulsate. The skin had not broken down over it. His heart was not displaced. His liver was enlarged two fingers' breadth below the costal margin. The Wassermann reaction was negative; blood and urine were normal. Roentgenologic examination

TUMORS OF THE CHEST WALL

Fig. 12.—Anterior view of Case 5, just prior to operation in 1930. The scar of a previous operation is seen, but is not broken down.

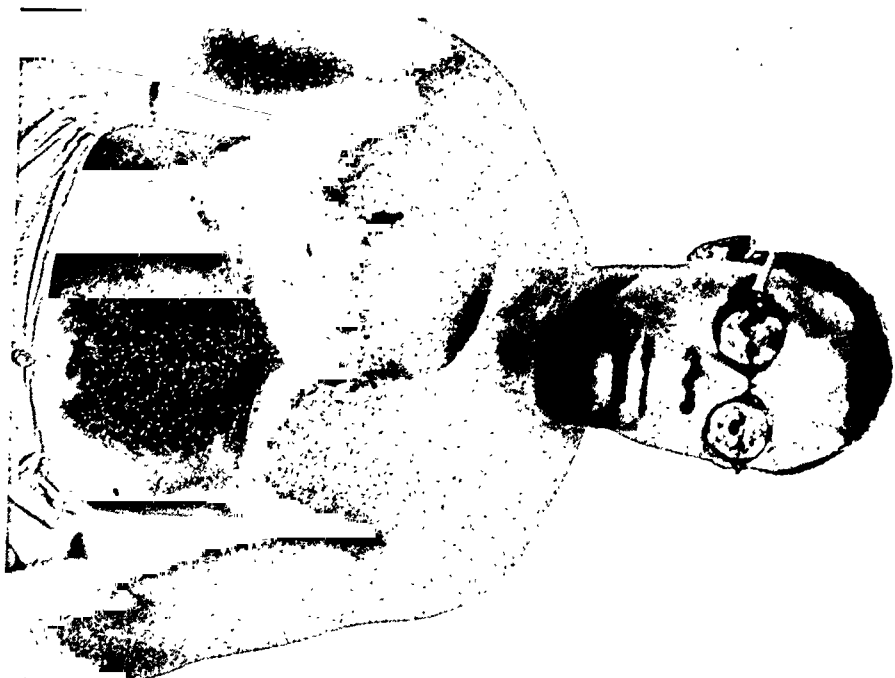
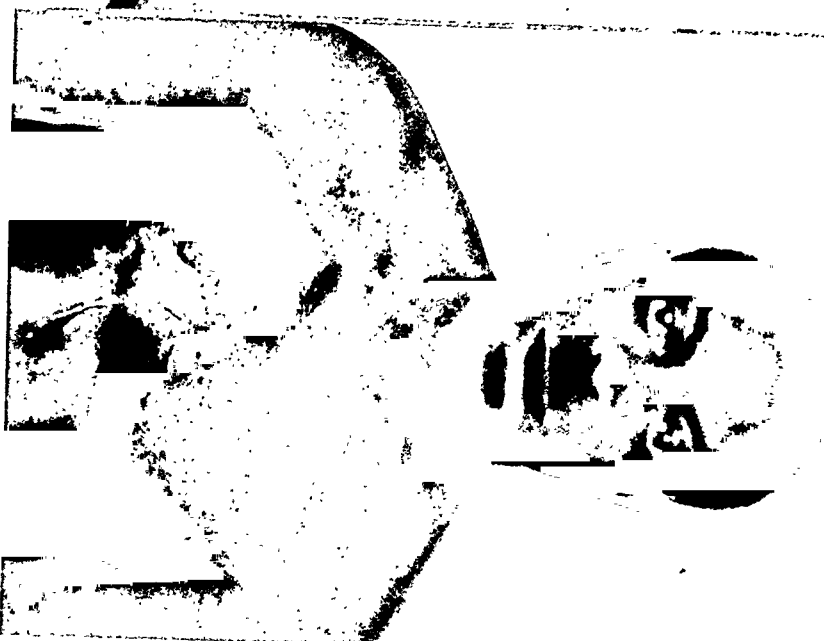


Fig. 13.—Lateral view of tumor of Case 5 on same date as Figure 12.



Fig. 14.—Case 5, nine months after operation. Wound healed, no evidence of recurrence yet visible.



showed an opacity in the upper two-thirds of the right chest, extending one inch above the clavicle and covering the axillary region. A lateral view showed a cup-like depression within the chest cavity, centering behind the right third and fourth ribs anteriorly, with a definite margin, no collapse of the right lung and no metastatic masses in the lung areas.

Operation September 11, 1930. A block dissection of the tumor, including the anterior portions of the second, third and fourth ribs with their cartilages, the right half of the sternum adjoining and the edge of the pericardium, was effected. As the tumor was lifted away with the chest wall, pale jelly-like material was expressed from the mass. Behind the tumor lay an intrathoracic cavity as large as a fist, lined with thickened pleura, as indicated in the roentgenogram, and the partly cut away covering of the pericardium. Each heart impulse could plainly be seen. This thickened pleura was not opened as it was too extensively infiltrated and the cavity seemed to extend down to the diaphragm, containing much mucoid-like material which was gently scooped out. There was one enlarged lymph node in the right axilla. A cigarette drain was inserted in the chest pocket and the skin was closed over the defect. Some fever persisted for ten days after operation, but no untoward complications followed and the wound healed.

The tumor mass, after removal, was globular and measured $20 \times 16 \times 10$ cm., partly covered by a skin flap measuring 14.5 cm. wide \times 20 cm. long. At one angle of this skin the breast remained unchanged. The tumor was firm throughout, assuming irregularly the consistency of cartilage. The cut surface was variegated with softened, deep-purplish and red areas up to four centimeters in diameter, the entire surface being glossy and translucent. No new bone was found, but cartilaginous areas were evident. The ribs and sternum showed erosion, but little bony reaction. An histologic diagnosis of chondromyxosarcoma with moderate irregularity of the cells and regressive changes, mostly in the form of mucoid degeneration, was made.

The tumor remained quiescent and giving no symptoms, he returned to his work (Fig. 14). On May 19, 1933, a few nodules were formed around the healed scar with some bulging tumor masses, one area the size of a lemon and three or four smaller ones. A sinus had developed in the scar below the level of the second rib, pin point in size, out of which fluid dropped when he leaned forward. This, he thought, was water from his bath, air bubbles being frequently mixed with the discharge. These bubbles were often seen emerging at a rate synchronous with the heart beat. He had gained considerable weight since the operation and was holding it. He felt very well.

Röntgen therapy was then started. In spite of this, the sinus enlarged, its edges became sloughing, gangrenous and ultimately foul smelling. Roentgenologic examination of the chest failed to reveal any metastases in the lungs and no enlargement of the intrathoracic pocket at the site of extirpation. The pulsating pericardium could be seen at the bottom of the opening which had to be dressed several times a day on account of the purulent discharge which could be made to spill over if he bent well forward.

By December, 1935, the condition had progressed until three fingers could be thrust into the chest orifice. The loss of weight and strength became so marked that he gave up work; he also complained of some pain in the left thigh. On examination, there was found to be an enlargement of the soft tissues of the left thigh, rather hard, not bony, attached to the femur beneath. There was also found a nodule appearing on the scalp of the vertex, not painful, fungating in character and bleeding if irritated (Figs. 15 and 16). Roentgenologic examination still failed to show further tumor advance or metastases in the chest. In the left thigh, the metastasis seemed not to be central in the femur, but to be outside of the bone pressing upon it. This was verified by roentgenologic examination which showed no osseous change.

Fearing a pathologic fracture of this bone and realizing the end was near, he was sent to a charity hospital. A biopsy was performed on the tumor mass on his scalp and various parts of the skeleton were rayed. These films showed no evidence of the spread of the tumor or metastases in the lungs and no metastases in any bones. The growths in

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the thigh and scalp were extra-osseous. The histologic diagnosis of the metastatic tumors was chondromyxosarcoma. Death occurred March 14, 1936, and no autopsy could be secured.

Case 6.—Female, aged 32, married, seen in July, 1933. Her complaint was a small tumor on the wall of the right side, just above the breast near the midaxillary line. There had been some thoracic pain, but no cough, dyspnea or hemoptysis. The mass was quite hard, was not connected with any palpable or visible mass in the breast, which was normal. The laboratory and general findings were normal. Roentgenologic examination demonstrated a collar button type of tumor shadow extending between the ribs, the external portion giving a deep shadow beneath the soft tissues without any evident damage of the ribs and the intrathoracic portion, well de-



FIG. 15.—Metastasis in scalp, a few weeks before death, of Case 5. Six years after removal of myxochondrosarcoma of chest wall.

FIG. 16.—Photograph of Case 5, a few weeks before death, six years after the removal of tumor. The sinus leading into the right thoracic cavity is seen surrounded by necrotic scar tissue and neighboring masses of local recurrence of the chondrosarcoma. The small metastasis in the scalp and the larger metastasis in the left thigh, both extra-osseous, are present.

marked, extending upward and downward into the right thoracic cavity in a semi-pedunculated manner. The inner portion had the appearance of a cyst-like mass with indistinct trabeculae, but was definitely connected with the extrathoracic bulge. A biopsy and operation were refused and although a definite diagnosis could not be reached, it was felt that the condition was not at that time malignant. The patient did not return after the examination.

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SOME ADVANCES IN THE TECHNIC OF THORACOPLASTY

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IMPROVEMENTS in the technic of thoracoplasty during recent years have more than doubled the percentage of patients whose tuberculous pulmonary cavities have become completely closed, and have decreased by more than half the percentage of deaths that occurred with the Wilms-Sauerbruch paravertebral and the Brauer subscapular types of thoracoplasty.

Although a large number of factors, with respect to operative technic and pre- and postoperative management, have contributed to this almost phenomenal improvement in results, only the most important will be considered in this article. The improvement has not been due to the exclusion of poor risk cases since the division of the modern operation into multiple small stages, as advocated by Alton Ochsner and Hedblom more than ten years ago, has resulted in the employment of thoracoplasty for many patients who could not have withstood a one stage or a two stage operation. The present extensive use of a thoracoplasty that is restricted to the upper part of the chest without a complementary permanent phrenic paralysis has greatly extended the indications for thoracoplasty and has made bilateral collapse therapy possible for certain forms of bilateral cavernous tuberculosis.

The restriction of every stage of a thoracoplasty operation to the removal of two, or rarely if ever more than three, ribs is undoubtedly the most important factor in the reduction of the operative mortality rate. Several years ago when four or five ribs were removed at a stage of the operation, grave cardiorespiratory decompensation, sometimes resulting in death, was a rather frequent postoperative complication. At present this complication, or death from other causes directly or indirectly due to operation, is exceptional. The resection of only two or three ribs at one stage permits the safe removal of great lengths of these ribs, which factor is chiefly responsible for the present high percentage of complete cavity closure. It is, however, obvious that as great sudden pulmonary collapse and dangerous paradoxical motion of the thoracic wall and lung may be produced by the total removal of only two or three ribs as by the partial removal of four, five or six ribs. The surgeon must, therefore, stage the costal resections in the horizontal as well as in the vertical direction, leaving as much of the anterior ends of the ribs as the relative mobility or rigidity of the posterolaterally decostalized portion of the thoracic wall indicates is necessary, in order to preserve a safe degree of stability of the thoracic wall and to prevent too great and sudden a pulmonary collapse. If, after two or perhaps three posterior stages have been performed, roentgenograms show that a pulmonary cavity is being prevented from complete closure by the remaining anterior costal stumps and cartilages,

these may be dealt with by one of the efficient modern types of anterior thoracoplasty operation, which then constitutes a stage of the whole thoracoplasty.

The division of the operation into three, four, or exceptionally five, stages, separated by intervals of approximately three weeks, would result in an incomplete collapse of those parts of the thoracic wall that were first decostalized, if provision were not made to prevent regeneration of ribs from the periosteum. Regeneration can be prevented efficiently if the dried periosteum is thoroughly scrubbed with 10 per cent formalin solution. Since permanent mobility of the decostalized portion of the thoracic wall is not desirable, only those parts of the periosteum that are protected from undue mobility by the rigid scapula and the heavy muscle posterior to, and just anterior to it, should be formalinized unless, as in empyema cases and some cases of fibroid phthisis, the anterolateral and infrascapular parts of the decostalized thoracic wall are found to be rigid at the time of operation.

The routine removal of the entire lengths of the vertebral transverse processes and the underlying necks of the ribs at, and somewhat above and below, the level of the pulmonary cavity or cavities, greatly increases pulmonary collapse in the costovertebral gutter and has an important influence in averting secondary thoracoplasty. I have an impression that the routine removal of the entire lengths of the transverse processes has, in my clinic, increased the closure of cavities from 10 to 15 per cent.

The old practice of resecting the lower ribs at the first stage of the operation so as to prevent the aspiration of secretions into the lower lung has been largely abandoned since experience has shown that the resection of the upper ribs first is, from a number of standpoints, safer. The removal of the upper ribs first has the additional great advantage of permitting the surgeon to conclude the thoracoplasty as soon as roentgenograms, sputum examinations and other signs show that the cavities have completely closed and that all the important lesions are controlled. In the great majority of cases this condition exists after only six, seven or eight ribs have been removed; the lower ribs are, therefore, preserved for useful respiratory function, which might be invaluable if collapse therapy should at any future time be necessary for the contralateral lung. If a temporary paralysis of the phrenic nerve had been produced before the thoracoplasty had been performed, the later return of diaphragmatic function would obviously add to the respiratory functional reserve.

Emile Holman has recently made the valuable proposal that when the lesions are so limited to the apical portion of the lung that no more than five or six ribs need to be resected, the scapula may be made to fall into the defect in the costal cage so as to produce maximal pulmonary collapse if the inferior portion of the scapula is resected.

Many other factors are responsible for the greatly improved thoracoplasty results of recent years. Important among them are the use of a 10 or 15 degree Trendelenburg position during the operation and for from 12 to 24

THORACOPLASTY



FIG. 1.—Comparison of the pulmonary collapse produced by the old paravertebral and the modern types of thoracoplasty.

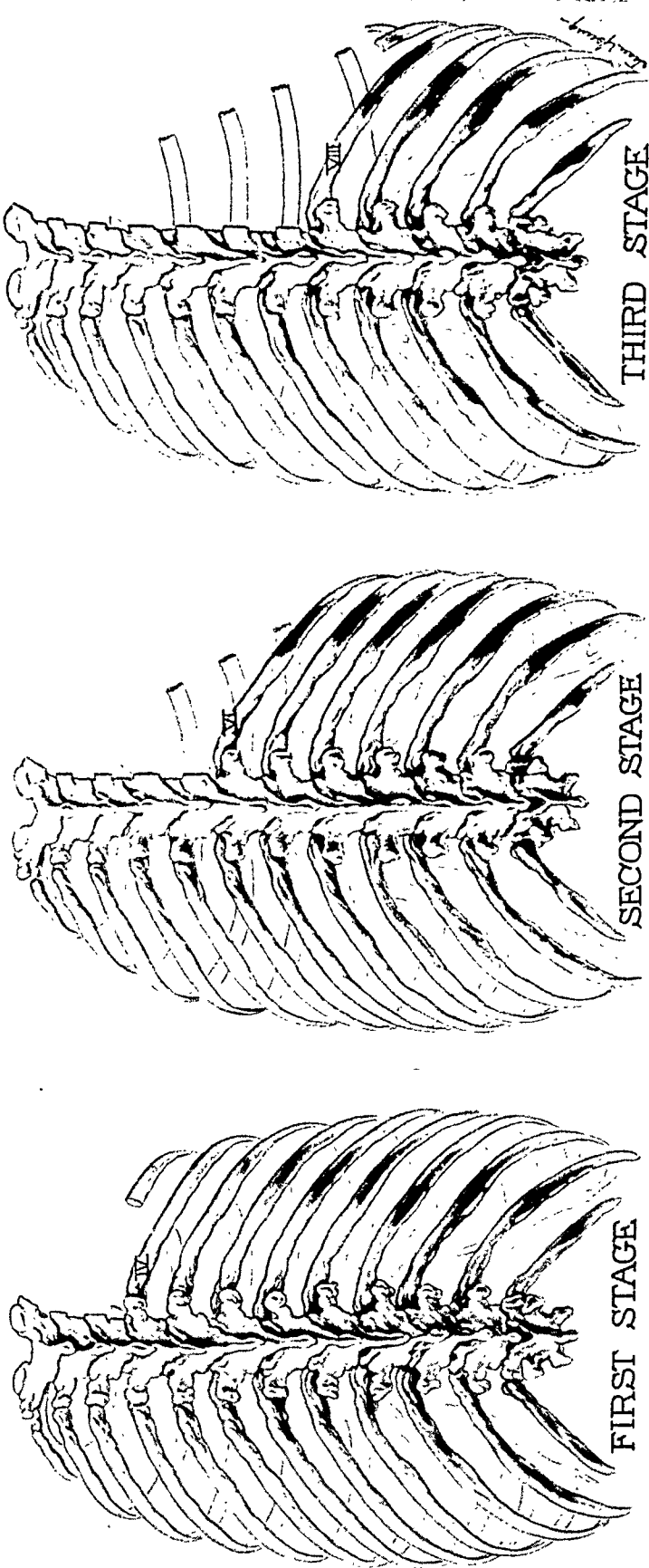


FIG. 2.—Approximate extent of costal resection in modern type of posterolateral thoracoplasty of seven ribs. At the first stage, all the first rib and cartilage, the posterolateral portion of the second rib, and a part of the posterior portion of the third rib have been resected. At the second stage, the remaining posterolateral portion of the third rib and the posterolateral portions of the fourth and fifth ribs have been removed. At the third stage, the posterior, and parts of the lateral portions of the sixth and seventh ribs have been removed. The transverse processes and the underlying necks of the ribs, except the first, have been entirely resected.

hours thereafter, so as to favor the gravitation of pulmonary secretions toward the mouth rather than toward the undiseased dependent lung. Immediately before and after operation, while the patient is in the Trendelenburg position, he should cough repeatedly and expectorate as much secretion as possible. Furthermore, he should cough at least every hour while awake for a day or two after operation so as to prevent the stasis of secretions and the development of pneumonia or new areas of tuberculous infiltration. The routine intravenous administration of 3,000 cc. of 5 per cent glucose solution during approximately the first eight postoperative hours keeps the patient in water balance during this important period, combats a tendency toward low blood pressure, and makes unnecessary the giving of fluids by mouth.

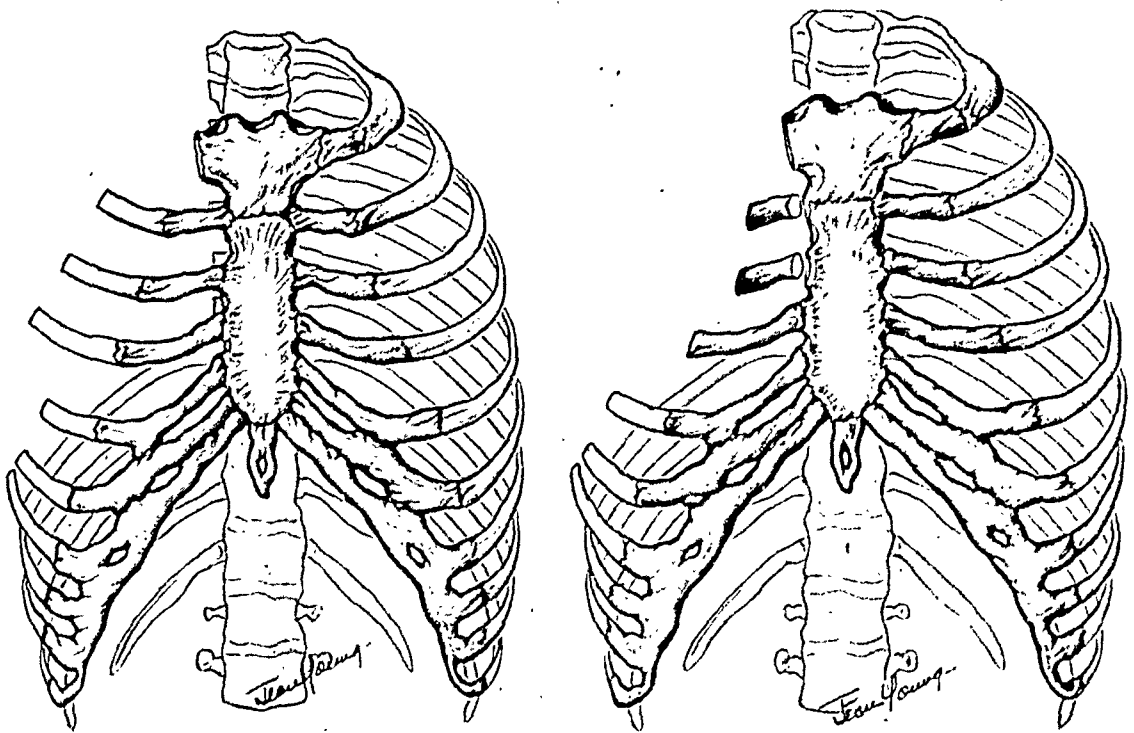


FIG. 3.—Haight type of anterior thoracoplasty. The left-hand drawing shows approximately the lengths of the anterior costal stumps remaining after completion of the posterolateral thoracoplasty illustrated in Figure 2. The right-hand drawing indicates the additional collapse produced by the removal of the second, third and fourth costal stumps and the parasternal division of the second and third cartilages. (From Haight, Cameron: *Journal of Thoracic Surgery*, 5, 453, 1936.)

In case an ineffective pneumathorax is present when a thoracoplasty is decided upon, the air should be allowed to become completely absorbed before the thoracoplasty is performed so that the danger of an operative opening of the thin, nonadherent parietal pleura, or of a sudden increase of pressure upon the lung and mediastinal organs by the falling in of the decostalized portion of the thoracic wall upon the closed pneumathorax, may be avoided. The gradual expansion of a partially collapsed, active tuberculous lung only occasionally proves harmful and need not be feared unless fever or other signs of increasing activity of the lesions occur, even though cough and expectoration increase and a partially collapsed cavity enlarges. If, however, a recurrence of fever, the roentgenologic finding of an increase in the parenchymal infiltration, or pain, dyspnea and persistent irritative cough from

unduly high negative intrathoracic pressure should occur, no further attempt should be made to cause the lung to expand completely. In such a case pneumothorax refills should again be given until the new tuberculous activity or the signs of unduly high negative pressure have subsided and then the thoracoplasty performed in the presence of the pneumothorax, air being aspirated before, during or immediately after operation so as to prevent unduly high intrapleural pressure. Many other technical factors bearing upon the safety and effectiveness of thoracoplasty might be considered but are beyond the scope of this article.

Haight and Alexander, in an article to be published, report that 119 of their patients have had the modern type of thoracoplasty during the two and one-half year period ending January 1, 1935. In April, 1934, all cavities of these patients were completely closed as indicated by roentgenograms made by the Potter-Bucky technic, and the sputum was continuously negative to concentrated specimen examination in 83.1 per cent, or in 93.4 per cent of the 106 living patients. Only 10.9 per cent of the 119 patients had died by the late spring of 1935 either from operation or tuberculosis; only 5.4 per cent of the 37 patients operated upon in the year 1934 had died by August, 1935. One hundred and two (96.2 per cent) of the 106 living patients have closed cavities in the lung of the side operated upon but three of them have positive sputum from open lesions in the contralateral lung.

In striking contrast to the figures just given are those I collected in 1925 from many clinics in different parts of the world which were using the old type of thoracoplasty: Thirty-six and eight-tenths per cent of 1,159 patients had closed cavities and negative sputa, and 38.7 per cent died a variable length of time after operation. The following figures collected by Hedblom and Van Hazel in 1934 for the 3,762 old and transitional types of thoracoplasty operations performed between 1925 and 1934 are approximately the same: 35.3 per cent practically symptom free and 33.6 per cent dead.

Although the figures cited in each of the preceding two paragraphs are not exactly comparable, since those in the second paragraph represent a longer average time after operation, the difference in the figures approximately represents the difference in effectiveness and safety of the old and new types of operation.

SUMMARY.—(1) Improvements in the technic of thoracoplasty during the last ten years have virtually halved the operative mortality rate and doubled the percentage of patients whose tuberculous cavities become completely closed.

(2) Among the more important technical improvements which have exerted an important influence in extending the indications for thoracoplasty as well as for various types of bilateral collapse therapy are the removal of no more than two or three ribs at any operative stage; the removal of greater lengths of the ribs; if maximal collapse is needed, the anterior ends of the ribs are removed at a separate stage so as to lessen the suddenness of pulmonary collapse and reduce dangerous paradoxical movement of the thoracic wall; provision for progressive pulmonary collapse by the prevention of re-

generation of ribs posterolaterally through formalinization of the periosteum; resection of the entire lengths of the vertebral transverse processes and the underlying necks of the ribs at, above, and below the level of the pulmonary cavity so as to increase pulmonary collapse in the costovertebral gutter; the removal of the upper ribs first and the preservation of the lower ribs for useful respiratory function when there are no lesions in the lower lung requiring collapse. A large number of other factors in the modern thoracoplasty operation have contributed to the reduction of the operative risk and in bringing about complete healing of the tuberculous lesions.

(3) Statistics are cited to show the striking improvement that has occurred in the results of thoracoplasty during the last ten years.

THE LATE RESULTS OF THORACOPLASTY IN THE TREATMENT OF PULMONARY TUBERCULOSIS

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THE operation of extrapleural thoracoplasty is well established as the method of treating certain types of pulmonary tuberculosis. However, the technic of the operation has changed considerably in recent years. Formerly, relatively short segments of the first 10 or 11 ribs were removed in all cases, usually in two stages, beginning with the lower ribs. At present, the tendency is toward a partial thoracoplasty involving the removal of very long segments of a few ribs over the diseased portion of the lung, thus preserving the function of the non-diseased areas. The partial thoracoplasty is begun at the upper limits of the thorax and continued downward until the desired amount of compression has been obtained. Sufficient time has not elapsed since the advent of the partial operation to compare the permanency of the results accomplished by it with those of the earlier complete operation. It would seem advisable, therefore, to record the late results in as large a number of cases as possible which have been operated upon according to the earlier technic, in order that a satisfactory comparison can subsequently be made with those resulting from the present procedure. A further reason for making such a report is to attempt to answer the questions: "What are the late results which can be obtained by complete thoracoplasty?" and "How lasting are such results?"

A partial thoracoplasty is commonly defined as consisting of the removal of segments of seven ribs or less. According to this standard, all of the cases in this report have been subjected to a complete thoracoplasty. They have all been operated upon by a technic the details of which have been described elsewhere,¹ and the principles of which are meticulous hemostasis, gentle handling of tissues, local anesthesia, the use of silk for ligatures and sutures and closure of the wound without drainage. In the earlier cases in this series, the operation was performed from below upwards, but beginning in 1932 the upper portion of the thorax was attacked first. In the later cases in the series much longer segments of ribs were removed, over the most diseased portions of the lung, than had been the case in the earlier ones, as it was becoming apparent that many of the cavities had not been closed by the resection of short portions of the ribs. By far the majority of the operations were performed in two stages, with a two week interval between them. At each stage, segments of at least four and frequently of five or six ribs were removed. At present never more than three ribs are removed at a stage, but practically the entire length of each of the first three ribs is resected.

It has been the experience of many surgeons that the resection of short rib segments is ineffectual in closing cavities and is directly responsible for many of the deaths and unsatisfactory results in their earlier cases. Even if a complete thoracoplasty is proposed, it is essential to remove long enough segments of ribs to completely close the cavity. In the 103 cases embodied in this report from two to eleven years have elapsed since the operations. Most of the patients had been ill with pulmonary tuberculosis for from three to five years; the shortest duration of the disease prior to operation was one year, and the longest 12 years. All of the patients had had unsuccessful attempts at sanatorial care and at artificial pneumothorax, and many had had a phrenicectomy performed.

Several different methods of classifying cases in order to indicate the results of thoracoplasty have been used. Probably the simplest is that of Bull² of Oslo, who in 1930 reported on 401 cases, some of which were collected. His classification was Group I.—Alive, able to work, practically symptom free, negative sputum; Group II.—Alive, able to do some work but not symptom free, positive sputum; Group III.—Unable to do any work, positive sputum; Group IV.—Results not evident; Group V.—Unable to be traced; and Group VI.—Dead at various time intervals. This classification was used by Hedblom and Van Hazel³ in their comprehensive report published in 1934, and is the one I propose to use. However, there are a few cases which cannot be fitted into the above classification and I have placed them in a Group I-A.—Alive, not entirely symptom free, able to do very little work but with negative sputum.

The results of thoracoplasty will vary with several factors. The more important ones of these are: (1) the care with which patients are selected for operation; (2) the type of operation performed, and (3) the type of convalescence which follows operation. The more strictly the indications for operation are adhered to, the better are the results. Thus Archibald⁴ found that among "good chronics" his operative mortality was 4.3 per cent; in the group of doubtful risks it was 4.2 per cent, whereas among the unfavorable cases it was 26 per cent. Brunner,⁵ reporting on 117 cases performed in Sauerbruch's Clinic, obtained 40 per cent cures in a group of cases with favorable indications, 14 per cent cures in cases with less favorable indications and no cures in the desperately ill cases. Table I indicates our experience in this regard.

TABLE I

TYPES OF PATIENTS OPERATED UPON

"Good risks."—62 cases, 59.6% are apparently well—22.6% have died.

"Doubtful risks."—27 cases, 40.7% are apparently well—29.5% have died.

"Unfavorable risks."—14 cases, 30% are apparently well—35.2% have died.

However, it must be remembered that if only the most favorable cases are selected for operation, the benefits of the operation will be denied to many patients, a considerable number of whom can be cured. It is advisable,

on the other hand, not to accept hopeless cases for operation on the plea that it gives them their only chance, for that type of patient will practically always die as a result of the operation. Several of the cases reported in this paper should never have been operated upon, and in the light of our experience would not now be thought suitable for operation. Careful observation by a competent internist, the use of blood transfusions and graded exercise may do a good deal towards converting a seemingly hopeless risk into a moderately good one.

Mention has been made above as to the type of operation which is considered most effective at the present time. Many of the early operations in this series were quite inadequate. As evidence of this are the 13 cases that had to have "supplementary" operations for cavities not closed by their original operation. The time to close the cavity completely is at the first series of operations. Supplementary operations have proved rather unsatisfactory in our experience. It is most important to bear in mind that the operation of thoracoplasty does not cure the patient at once, but that it makes conditions such that nature can more readily heal the cavities and other lesions in the lung. Consequently a sufficiently long and properly managed convalescence is essential following operation. All of the patients included in this report were kept at absolute bed rest for at least six months after operation. If the sputum was still positive at the end of that time, the bed rest was continued up to one year before additional collapse therapy was advised.

In considering the results obtained by thoracoplasty, it should be borne in mind that the patients upon whom the operation is performed are chronically ill and have been so for years, that they are frequently very poor risks and that without the benefits of operation the outlook for all of them is practically a hopeless one.

Table II shows the late results in the patients that fall into Group I, *viz.*, those that are living, are able to work, are symptom free and have a negative sputum.

TABLE II

GROUP I:—ALIVE, ABLE TO WORK, PRACTICALLY SYMPTOM FREE, NEGATIVE SPUTUM

No. of Cases 103	Years after Operation											Total	Per Cent
	2½	3	3½	4	5	6	7	8	9	10	11		
	2	6	3	3	7	6	5	10	7	8	1	58	56.3

In Hedblom's report³ in 1934 of 200 cases of his own, 41 per cent fell into Group I. He also collected 1,235 from the reports of eight authors and of these found that 35.4 per cent were in this group. At least two years had elapsed since operation in each instance. Graham⁶ reports that 29.3 per cent of his 75 cases, in which the operation had been performed for at least two years, were able to resume normal activities and had negative sputum. Due to the fact that a more complete collapse of cavities in the

lung is being obtained with the present operation, I believe that an increasing number of patients will be found in this group. The occupations of the patients in Group I are shown in Table III, together with any other data of interest since operation. Table IV shows the number of patients falling into Group I-A, *i.e.*, alive, able to do some work, not symptom free, negative sputum.

TABLE III

PRESENT OCCUPATIONS OF PATIENTS IN GROUP I

Housewife—29	Maid—2	Unemployed—5	Engineer—1
Salesgirl—1	Nurse—1	Elevator operator—1	Clerk—4
Stenographer—1	Technician—1	Houseman—1	Orderly—2
Telephone oper.—1	R. R. attendant—1	Gen'l light labor—3	Bookkeeper—1
	Taxi driver—1	Car checker—1	Merchant—1

Eight of the female patients have married since operation; four of them have had children who are at present 6 months, 4 years, 5 years, and 7 years old.

TABLE IV

GROUP I-A:—ALIVE, NOT SYMPTOM FREE, ABLE TO DO VERY LITTLE WORK,
NEGATIVE SPUTUM

No. of Cases	Time Elapsed Since Operation				Total	Percentage
	3 yrs.	6 yrs.	7 yrs.	10 yrs.		
103	1	1	1	1	4	3.9%

One patient has a severe bronchiectasis.
Two patients have marked emphysema.
One patient has moderate cardiac involvement and some emphysema.

The number of patients in Group II, *viz.*, alive, able to do some work, not symptom free, positive sputum, is given in Table V.

TABLE V

GROUP II:—ALIVE, ABLE TO DO SOME WORK, NOT SYMPTOM FREE, POSITIVE SPUTUM

No. of Cases	Years after Operation				Total	Per Cent
	3	5	9	11		
103	2	1	1	1	5	4.8

Occupations: Lithograph artist—1. Housekeeping—4.

In comparison with the figures in Table V are those of Bull's² which are 11.6 per cent; of Hedblom's³ which are 5 per cent and of Hedblom's collected series of 1,235 cases which are 10.9 per cent.

The number of patients that fall into Group III, *i.e.*, alive, unable to work, not symptom free, positive sputum, is shown in Table VI.

TABLE VI

GROUP III:—ALIVE, UNABLE TO WORK, NOT SYMPTOM FREE, POSITIVE SPUTUM

No. of Cases	Years after Operation							—Total	Per Cent
	2½	3	4	5	6	9			
103	1	2	1	3	1	1		9	8.7

The 27 deaths among the 103 patients upon whom this report is based fall naturally into two groups, *i.e.*, the early and the late. The confusion as to what constitutes an operative mortality can be avoided if the deaths are reported with the time interval after operation at which they occurred, since practically all of the deaths within eight weeks are directly due to operation. The large number of early deaths and the fact that they constitute nearly one-half of the total deaths is one of the striking features of all reports. Graham, Singer and Ballou⁶ in 1935 reported an operative mortality of 13 per cent in a series of 2,642 collected cases and one of 8.5 per cent in the first four weeks in a series of 140 cases of their own. Hedblom³ in 1934 in a compilation of 3,811 cases occurring in 24 series, stated that the mortality in the first eight weeks was 10.5 per cent with individual variations from 3 to 21 per cent. His own eight week mortality in 161 patients was 10.5 per cent. Table VII shows the time at which the early deaths in our series occurred with the cause of death in each instance.

TABLE VII

GROUP IV:—PATIENTS THAT HAVE DIED EARLY DEATHS

Of the 27 deaths 9 (8.7% of the total number of patients) occurred within the first six weeks as follows:

2 days	3 days	4 days	7 days	9 days	14 days	35 days
2	1	1	2	1	1	1
Causes of Death						
Medias- tinal Flutter	Wound Infection	Acute tbc. Pneumonia in Good Lung	Cardiac	Lobar Pneu- monia	Pulmonary Hemorrhage	Acute Auto- tubercu- linization
1	1	3	1	1	1	1

Except for more careful selection of cases there is little that can be done to decrease the number of late deaths most of which are due to tuberculosis in some form. It should be possible, however, to lower the mortality which occurs in the first eight weeks. In a combined series of 319 early deaths recently reported,³ it was found that wound infection was responsible for 8.3 per cent, shock for 8.3 per cent, heart failure for 21.3 per cent, mediastinal flutter for 2.3 per cent and pulmonary complications for 38 per cent. The number of deaths occurring from shock can certainly be decreased by an operative technic that demands careful hemostasis and lack of trauma; and by dividing the operation into many stages, no one of which is of enough magnitude to cause a dangerous degree of shock. No patient in our series died from shock following operation. The resection of not more than three ribs at a single stage will do much to prevent shock and abolish mediastinal flutter.

I am in accord with Graham⁶ in believing that there are relatively few true cardiac deaths following thoracoplasty and that many patients whose deaths are ascribed to heart failure really die of autotuberculinization and acute

tuberculous pneumonia of the good lung. Allen⁷ believes that the anoxemia due to an insufficient vital capacity remaining after collapsing one lung is frequently confused with heart failure—a feeling which I likewise share. A careful preoperative study of the lung volume as advocated by McIntosh⁸ after the method of Christie,⁹ is a definite aid in determining the reserve upon which a patient can rely after operation. The highest percentage of early deaths is due to pulmonary complications, the chief one of which is an acute tuberculous pneumonia involving the good side. Undoubtedly some of these follow a reactivation of a supposedly healed focus in the good lung. The added “strain” thrown upon the sound lung was commonly thought to be responsible for this but Churchill¹⁰ feels that this factor may be greatly discounted. He has shown that if a harmful strain is ever thrown on the collateral lung, it is most likely through the increase in the rate or depth of breathing which results from the increased carbon dioxide content of the blood entering the general circulation from the collapsed, but actively circulated lung. A large percentage of the cases of acute tuberculous pneumonia in the good lung is due to the aspiration into it of the contents of cavities which are compressed when the diseased lung is collapsed. The mechanism by which this occurs has been well described by McCordock and Ballou.¹¹ They state that the development of acute tuberculous pneumonia in the good lung in many cases depends upon the amount of compression obtained and upon the location of such compression. It is the squeezing out into the bronchial tree of the infected contents of tuberculous cavities and the aspiration of such contents into the already sensitized good lung that produced the tuberculous pneumonia. The experimental work of Rich and McCordock¹² has shown that such a mechanism does exist and that by it massive tuberculous pneumonia may be produced within a few days. The latter authors also have shown that the severity of the pneumonia is dependent upon the number of bacilli which are aspirated into the good lung—a fact that explains the recovery of some patients and the rapid death of others. A considerable amount of edema accompanies this type of pneumonia and on this account many cases are unrecognized and death is attributed to edema of the lungs. In this connection the experience of Allen⁷ is interesting. In one of the hospitals in which he operated, he had not for seven years had a single instance of acute tuberculous pneumonia following a thoracoplasty operation. He ascribed this to the fact that he had to operate at that particular hospital only in the afternoon and by that hour the patients had cleaned their lungs during their morning coughing even better than they could have by postural drainage. It is largely for fear of aspiration during operation that I have performed all of my operations under local anesthesia. Hedblom quotes Denk³ as believing that postoperative mortality is influenced by the season of the year at which the operation is performed and states that between October and March his mortality was 13.8 per cent in 165 operations, whereas between April and September, it was only 4.5 per cent. Hedblom’s³ own experience, however, was just the opposite with a mortality of 2.1 per

cent for winter and 6.2 per cent during the summer. Our series shows 4.3 per cent from October to March and 4.4 per cent from April to September.

Apparently there is little uniformity of opinion as to the relationship between sex and mortality rate or between the side operated upon and the early mortality. This series shows a higher mortality rate for females (9.5 per cent) than for males (7.5 per cent) and a higher rate (10.1 per cent) for left-sided than for right-sided operations (9 per cent); a higher rate for the left side in males (5 per cent as compared to 2.5 per cent for the right side); and for the left side also in females (6.2 per cent as against 3.1 per cent for the right side).

TABLE VIII

GROUP IV:—PATIENTS THAT HAVE DIED LATE DEATHS

Of the 27 deaths 18 (17.4% of the total number of patients) occurred after 3 months following operation as follows:

3 mos.	4 mos.	1 yr.	1½ yrs.	2 yrs.	3 yrs.	3½ yrs.	4½ yrs.	6½ yrs.	8 yrs.	9½ yrs.
1	3	3	1	1	3	1	2	1	1	1
<i>Causes of Death</i>										
Tuberculosis of the Good Lung	Generalized Tuberculosis		Peritonitis Following a Rup- tured Cecal Ulcer		Cardiac		Cerebral Hemorrhage		Mediastinal Lympho- sarcoma	
9	5		1		1		1		1	

It will be noted in Table VIII that 83.3 per cent of the late deaths were due to tuberculosis in some form, usually more often a spread of the disease to the good lung. This has been the experience of other authors. Three of the late deaths in this study were due to causes unrelated to operation or to the disease and occurred in patients who were alive, with negative sputum and working nine and one-half, three, and three and one-half years after operation.

SUMMARY

(1) A series of 103 cases of pulmonary tuberculosis which were treated by thoracoplasty is reported.

(2) At least two and one-half years have elapsed since operation in every case and as much as 11 years in some of them.

(3) Of the 103 patients—58 are working and have negative sputum; four others have negative sputum, but are unable to work; five are able to do some work but still have a positive sputum; nine are unable to do any work and have positive sputum; and 27 are dead.

(4) The causes of the deaths have been analyzed. Emphasis is laid on the large number of early deaths following operation.

(5) Nearly all of the late deaths were due to tuberculosis in some form.

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THE USE OF INTERCOSTAL MUSCLE IN THE CLOSURE OF BRONCHIAL FISTULAE

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THE large majority of bronchial fistulae uncomplicated by persistent pulmonary disease heal spontaneously or can be cured by relatively simple surgical measures. Some, however, do not respond readily to the common methods of treatment. Among these, in our experience, are the fistulae that follow drainage of central abscesses of the lung. In many such cases the terminal condition is as illustrated in Figures 1 and 2. A more or less cylindrical channel about one-half inch across and one to two inches in depth represents the line of drainage. The walls of this channel are widely separated during inspiration and closely apposed on expiration, the result of this constant movement being to retard healing indefinitely. The operative procedures required for the opening of the original abscess will have usually destroyed so much of the adjacent tissue that grafts from the superficial thoracic muscles cannot be found for closure of the fistula. In the treatment of several of these cases we have successfully used, as plastic material, intercostal muscle, not infrequently taken from a space a considerable distance from the fistulous opening.

The intercostal muscle possesses almost every characteristic desirable in a muscle flap: it is easily separated from the surrounding tissues; it retains intact its vascular and nerve supply and has a mobility rarely obtained in any other muscle that can be used for plastic work, and that without impairment of its circulation.

Operative Procedure.—The scar of the original wound is excised and one or both margins are widely enough retracted to expose the nearest intercostal muscle uninjured by the primary operation. While the muscle can be dissected from its bed without resection of the adjacent ribs, in practice it is better to remove these superiosteally first. The operation can then be carried out more rapidly and with less danger of injuring the blood supply of the proposed transplant. The structure and strength of the thoracic cage is very little if at all affected by the more extensive procedure. The ribs having been resected for a sufficient distance to provide a proper length of graft, the muscle is cut across anteriorly and stripped from the underlying pleura (Fig. 3). The free end is then implanted into the depth of the fistulous channel and held in position by a few interrupted catgut sutures (Fig. 4). The wound is then closed, a small tube only being left for drainage. Except for a slight, blood tinged expectoration lasting a few days, there have been no complications. Healing has taken place promptly in four of the five cases operated upon. In

one patient an unrecognized bronchiectasis was the presumable cause of failure.

Though it is somewhat outside the scope of this paper, we have also used a modification of this procedure as a primary method of treatment in a case

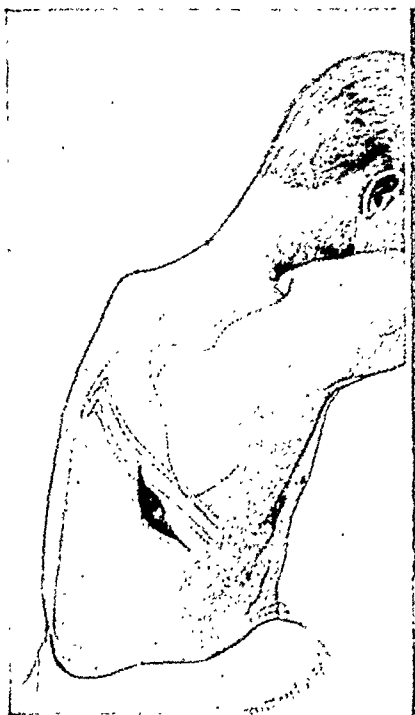


FIG. 1.—Persistent bronchial fistula following drainage of abscess of the lower lobe.



FIG. 2.—Enlargement of Figure 1 illustrating cylindrical channel leading to the fistulous openings.

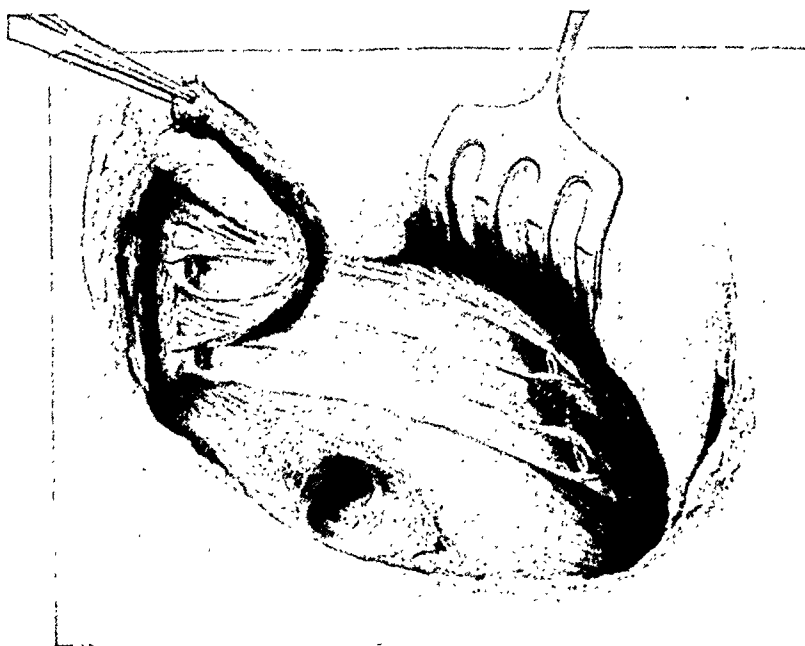


FIG. 3.—Preparation of the intercostal muscle graft.

of chronic abscess of the lung. The abscess, of six months' duration, lay in the midaxillary line immediately beneath the seventh and eighth ribs on the right side. As viewed under the fluoroscope its shadow did not move with respiration and it was apparently fixed to the chest wall over a considerable

area. Through a lateral oblique incision the seventh and eighth ribs were resected subperiosteally for a distance of six inches. The intercostal muscle was then separated from the pleura and retracted upward to permit a visual and digital examination of the latter structure and to determine its relationship to the underlying lung. As the pleura was obviously obliterated, the wound was thoroughly "bipped" and the abscess opened. The cavity was somewhat smaller than a baseball in size, contained a thick purulent exudate and presented a smooth lining in which were visible the openings of several fistulae. It was felt that convalescence might be shortened by partially filling



FIG. 4.—Implantation of the intercostal muscle into the depth of the fistulous tract.

the cavity with the intercostal muscle. This was done much as in the cases cited above, the intercostal muscle being curled within the hollow and held in place by a few sutures and some light gauze packing alongside of which a tube was placed as an additional safeguard. Otherwise the wound was closed. Healing took place very rapidly and so far as we could tell no air escaped through the wound at any time. The incision was completely closed in five weeks and the patient has remained well.

DISCUSSION OF THE PAPERS OF DOCTORS SPEED, ALEXANDER, CARTER AND SHENSTONE

DR. HOWARD LILIENTHAL (New York, N. Y.).—You have had the privilege of listening to unusual and in some instances epoch marking papers. I shall confine my remarks particularly to those on the surgical treatment of tuberculosis. Doctor Carter is to be complimented on his pronouncement, that I have always believed in and have ventured to publish, that the surgeon has a moral obligation to patients with tuberculosis who appear doomed unless something miraculous happens. It will happen if enough of these patients are treated surgically. The only thing that would prevent my operating in a case of this sort, or almost the only thing, is that there should be sufficient functioning lung to sustain life in a fairly normal manner. Otherwise, I do not care whether they have laryngeal, peritoneal, or bone tuberculosis—and I have had them all three in one patient, for that matter. If there is enough

functioning lung to keep the patient alive he ought to be given a chance through surgery, if the case is technically operable, and success will follow in enough instances to prove the truth of this principle.

There is one thing that I have noticed which has not been presented, and I have not seen it mentioned elsewhere. My attention was called to it by Doctor Amberson in New York in a case in which a patient died following an upper stage thoracoplasty from infection of the opposite lung, in which every possible effort was made to prevent a spill-over at the operation, which I am quite certain did not occur at that time. He developed a peculiar cough, with a mobile mediastinum, which Doctor Amberson described as a *paradoxical cough*, meaning that during the period just before the expulsive part of the cough, when the larynx was still closed, there was, literally, a cough into the opposite lung. As a matter of fact, postmortem examination also showed that the opposite lung was actively diseased.

Permit me to mention very briefly a paper that I have sent to the Journal of Thoracic Surgery, in which I describe a new form of an apicolytic thoracoplasty. I am convinced that in apicolytic thoracoplasty, with or without further thoracoplasty, the first rib does not need to be cut. I have had experience in six cases with this procedure, but that is sufficient to show that the immediate result in cases of this sort may be good. If the extrapleural space, that you have secured, is packed with rubber dam and left in place for four or five days, and then drained from below, the lower surface of the first rib acts as a perfect buffer for pushing the infected apex down, with obliteration of the pulmonary cavity. One advantage in saving the first rib in this way, and without prejudice to the operation otherwise, is that there is no danger of injuring the large neighboring vessels and nerve plexus during the manipulation, and that, therefore, the neuritis which so frequently follows, will not occur. That is entirely done away with, and it is an advantage well worth considering.

Doctor Alexander's paper was excellent. Most of the things that he does are, and I have greatly enjoyed hearing him. He speaks of operating in front of the original incision, when secondary operation is necessary to take away more rib. I used to do that, but I do not do it any more, and I doubt that it is ever necessary. At least it has not been, so far, in my cases. Through the original incision, the chest having been already pretty well collapsed, you can, with little trouble and with almost no hemorrhage, work around to the cartilages and take away as much rib as may be necessary. I do not believe that Doctor Alexander will continue operating through another incision when he has once given this a fair trial.

As to the formalin method of preventing the formation of rigid bone, it seems to me that I would require a successful demonstration of its harmlessness before I would want to employ it. As it is, when you take away large sections of rib, you are quite apt to get a mobile part of the chest wall, which I think in tuberculosis is a great disadvantage. The desideratum is *rigidity* in the new position of the chest wall.

For the last two years I have used electric surgery for the skin incision, and electrocoagulation for taking care of the vessels, except those that spurt, notwithstanding its application; these are tied. In a secondary operation, when I had not taken enough of the ten ribs away at the first procedure, I was able to perform the entire operation and take out more of all the ten ribs, almost to the cartilages, without using a single piece of catgut. Perfect primary union followed. This method will not only save a lot of time but will be extremely valuable. It cannot be used, by the way, when ethylene or cyclopropane is being employed, for obvious reasons. Also the incision

through the skin has to be made quickly and there must be a current that will deliver the kind of cutting electricity which you may use at high speed. Otherwise there is danger, of course, of slow healing.

There is one question I want to ask Doctor Shenstone about the abscess that was so perfectly cured by the intercostal muscle flap. Was that a putrid abscess?

DR. MARTIN BUEL TINKER (Ithaca, New York).—There are three things I should like to bring out in connection with these interesting papers.

In the first place, Doctor Lilienthal has just mentioned the use of electro-coagulation in this work. Those of you who have used it know how much time it saves. You realize, too, that with the electric cutting current you get sealing of the lymphatics and blood vessels which prevents infection of your wound. Those are two decided advantages. And the third is that you do not leave foreign material in the wound. Doctor Lilienthal in another discussion called attention to the fact that in operating upon the chest the current should not be used if you are working in the vicinity of the heart.

Doctor Speed's report of the case of tumor of the chest wall associated with tumor of the liver is, I believe, the only tumor of the character on record. It was a very formidable procedure and required a lot of courage to go into the peritoneal and chest cavities as extensively as he did, in order to remove the large liver tumor in connection with that of the chest wall. He failed to say that this woman not only lived but has borne two children.

The third point I should like to bring out in connection with Doctor Speed's paper is the frequency of tumors of flat bones, and particularly of the chest, in connection with tumors of the thyroid. He spoke of adenocarcinoma. You are all familiar with the paper of Cohnheim, published nearly 50 years ago, in which he called attention to the fact that certain tumors which clinically and pathologically are apparently benign, metastasize to the flat bones. Some French observers believe that if we search far enough we find actual malignancy, but I think there are some 75 instances of recurrence of this kind in which the tumor apparently was perfectly benign.

DR. CASPER F. HEGNER (Denver, Colo.).—Doctor Alexander covered the subject and left nothing for discussion. We all know of the work he has done in the surgery of tuberculosis.

The character of the lesion within the lung, or within the pleura, the extent of the lesion as well as its location, determine the length of the segments of the ribs to be removed. I believe, as to the lateral and the anterior costectomy, if sufficient length of rib is removed with the transverse processes, these operations will be unnecessary. Secondary operations, of course, can be approached through the posterior incision. No matter how many operations have been performed, it will rarely be necessary to employ other than the posterior approach. I have not found difficulty solely with the size of the cavity. Of course we secure the necessary relaxation in order to permit nature to cause fibrosis of this cavity. More difficulty has been experienced with the character of the wall of the cavity, and the nature of the surrounding pericavitary zone. Sufficient deribbing must be effected in order to secure a degree of relaxation sufficient to permit nature to initiate fibrosis.

We also had a little difficulty in the number of ribs removed. If we remove the seventh rib we have to take the eighth in order to eliminate the snapping of the scapula, which causes a great deal of discomfort.

In regard to the application of formalin, we have used that a good many times. It does not entirely prevent regeneration of the ribs, but it does retard

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it sufficiently to permit the interval between stages to be very much more prolonged.

Tumors of the chest wall, referred to by Doctor Speed, have been interesting. We have had three cases of this myxofibrosarcomatous condition of the chest. One was in a man of 70, in whom two or three operations had been performed, but it has recurred. I think the multiplicity or complexity of the cytologic examination is very much more important than a negative report from the pathologist. Whenever you have a multiplicity of cellular elements, you know it is either malignant or will become so.

DR. STUART W. HARRINGTON (Rochester, Minn.).—Tumors of the chest wall often present greater surgical problems than tumors that are entirely within the thoracic cage, because surgical removal of those involving the thoracic wall and projecting into the thoracic cavity are associated with all the dangers of a transpleural operation as well as necessitating reconstruction of the thoracic cage, which should be completely closed. Doctor Speed pointed out that the majority of these tumors are malignant, which is of great surgical importance because they demand radical removal, which often involves large areas of the chest wall.

My experience consists of 39 cases in 30 of which the tumors were malignant and in nine, benign. Benign tumors are much more satisfactory to treat, for they are cured by complete removal of the tumor, and surgical removal is usually not associated with extensive removal of the chest wall and does not require such extensive reconstruction of the thoracic cage. Cases of malignant tumor are not so gratifying from a surgical standpoint, for they not only present greater operative risk but the disease is usually so extensive at the time of operation that complete eradication of it is rarely possible. The average length of life in the 30 cases in which operation was performed has been two years and five months. Discouraging as this is from the standpoint of results, some patients apparently are cured. One patient of this series who presented an osteosarcoma which originated from the rib and projected into the thoracic cavity, is now living without evidence of recurrence 11 years after radical operative removal of the growth.

I think the surgical problem depends a great deal on the situation of the tumor. It might be said that the more favorable tumors are those which are situated posteriorly and which do not involve the spine. The surgical difficulties increase when they are situated anteriorly in the chest wall; this is attributable to the increased difficulty of complete closure of the thoracic cage after removal of the growth. Complete closure of the thoracic cage is more easily accomplished following removal of the posterior tumors because the muscles of the posterior chest wall can be utilized in the closure of the thoracic cavity. As you go toward the sternum and diaphragm, there is increased difficulty in reconstructing the thoracic cage.

I shall present three cases very briefly.

Case 1.—The first case is that of a benign chondro-osteoma originating in the chest wall and extending into both anterior and posterior thoracic cavities. The difference in the roentgenologic shadow of this tumor in the various roentgenograms demonstrated the value of multiple roentgenograms, particularly of lateral as well as of anteroposterior views, in all cases of intrathoracic tumor. The lateral views in this case showed the tumor to project well into the posterior thorax. It was removed through a posterolateral incision. The anterior portion of the tumor was removed transpleurally through this incision, without incising the skin of the anterior chest wall. This permitted complete closure of the defect, posteriorly, with the scapula and muscles of the posterior thoracic wall. The patient obtained a very satisfactory result and now more than four years have elapsed since operation. He has a flaccid anterior chest wall in the area where

the tumor was removed which is troublesome only when a cold develops; then it is necessary for him to support the chest wall when coughing.

Case 2.—The second case is that of a large, recurring malignant endothelioma of the lower chest wall involving the diaphragm. Surgical removal of this tumor required very extensive removal of the lateral chest wall, including about one-fourth of the diaphragm. The opening in the abdominal cavity was closed by suturing the paralyzed diaphragm, after interruption of the phrenic nerve, to the chest wall above the area of the chest wall. The defect in the chest wall was closed with the posterior muscles. This patient lived two years and three months after the operation and died of recurrence.

Case 3.—The third case is that of a malignant tumor in the posterolateral chest wall. The growth involved the rib and proved to be an osteogenic sarcoma of moderate size. The growth was removed in two stages. The first stage, directed to walling off the pleural cavity, failed, as a pleural effusion developed, necessitating immediate transpleural removal of the growth. The man made a satisfactory recovery and is now living, 11 years after operation, with no signs of recurrence. This case again exemplifies what Doctor Speed has emphasized in his presentation, namely, that the most important consideration relative to malignant growths of the chest wall is their early radical removal.

DR. OWEN H. WANGENSTEEN (Minneapolis, Minn.).—About 20 years ago, Doctor Kanavel of Chicago pointed out the great virtue of pedicled muscle flaps in the closure of cavities of diverse natures. Those of us who have employed this expedient for such purposes can attest its worth. It was Abrasanhoff, a Russian surgeon, I believe, who first employed a pedicled muscle flap to secure closure of a bronchopleural fistula. He first sutured it over the bronchial stoma and later recommended implanting a slip of muscle into the fistulous tract in the lung in suitable cases. Doctor Pool has also, together with one of his associates, Doctor Garlock, extolled the merits of this method.

It is, to be sure, only the persistent bronchopleural fistula in which attempts at operative closure of this abnormal communication are indicated. The ordinary bronchopleural fistula which contributes to the continuance of empyema and the development of chronic empyema, usually closes spontaneously with the establishment of adequate and dependent drainage of the residual empyema cavity. In the presence of a suppurative process in the lung, which is still active, a bronchopleural fistula serves a useful purpose and efforts directed to obliterate it are not indicated.

That viable muscle tissue resists digestion is well illustrated in its survival in a chronic duodenal fistula, into which I implanted such a pedicled muscle flap some years ago. This fistula had apparently followed a nephrectomy and had remained refractory to all the usual methods of closing such a fistulous opening. Success attended implantation of a pedicled muscle flap.

The bronchial fistulae which, in particular, have concerned me are those coexistent with a large empyema cavity. I have had an interesting experience with two such cases in which multiple stomata were present. In each instance, after the prolonged establishment of adequate drainage, a pedicled muscle flap was mobilized and sutured over the stomata. Implantation was impractical because of the number of openings. The improvement in each case was startling; the pleurocutaneous wounds closed entirely and the patients remained afebrile. In each instance, after the elapse of some months, the patients became febrile again, owing to the accumulation of fluid in the persistent pleural cavity. A number of years ago (1920) Doctor Heuer reported attempts at sterilizing empyema cavities and closing them without obliterating them. The early favorable issue attending closure of the bronchial stomata in the two instances referred to above lent temporary confirmation to Heuer's suggestion that this objective might be accomplished. In both instances,

however, subsequent drainage and obliteration of the residual empyema cavity was found necessary.

The use of intercostal muscle as suggested by Doctor Shenstone for implantation into a broncho-pleural fistulous tract would appear to be a very simple and readily available expedient. I should like to refer in this connection to another use of the intercostal muscle bundle which I have practiced in the treatment of empyema. In a large empyema cavity with rigid walls, it is frequently found necessary to sacrifice, after adequate decostalizing, the soft tissues of the chest wall, that is, the parietal pleura and the intercostal muscle bundles together with their accompanying blood vessels and nerves, in order to obliterate the empyema cavity. Such a procedure, unfortunately entails section of the nerves to the chest wall, and when sacrifice of the lower intercostal nerves, particularly from the sixth to the ninth or tenth, is made, a large abdominal hernia is likely to develop. In 1932, when operating upon such an empyema, it occurred to me that the intercostal nerves might be preserved by a process of ribboning, in which, after excision of ribs, long horizontal incisions were made in the avascular rib beds, converting the intercostal muscle bundles and thickened parietal pleura into a series of parallel ribbons. By excising wedges from the thickened parietal pleura at either extremity of the incision, these ribbons were made to fall in and were used at the same time as a fill-in substance to help obliterate the empyema cavity. To date, this procedure has been used in three instances with large chronic empyema cavities, with satisfactory results, and abdominal hernia has been averted. The details of the operative technic of this procedure were described in the *Journal of Thoracic Surgery*, 5, 27, October, 1935.

DR. EVARTS A. GRAHAM (St. Louis, Mo.).—I should like to speak briefly first about the subject of bronchial fistulae.

Doctor Bettmann of Chicago, some ten or 12 years ago, called attention to the fact that the normal mechanism of healing of a bronchial fistula is by circular contraction. Bronchial fistulae will, in my experience, always heal if they have a chance to contract in a circular direction. If they do not have that opportunity, they will not heal. Consequently, in planning an attack on a bronchial fistula, we have, it seems to me, one or two ideas which we can utilize. We can either mobilize the lung so that circular contraction may occur, or we may plug the bronchus with something so that circular contraction will not be necessary.

The use of muscle laid against the opening of a bronchial fistula, is an effort to make it close, is an old procedure, but one which, at least in my experience, has often failed. Doctor Pool, however, a few years ago, called attention to the great advantage in using muscle, and plugging it into the bronchus. Now you can see, in the light of what I have just said about circular contraction, the great virtue of this principle of plugging the bronchial opening rather than laying muscle against it, because if the bronchial opening is plugged with the muscle flap, the lumen is completely filled with the growing tissue which is put in there, circular contraction is no longer necessary, and, to make a long story short, the closing of the fistula is accomplished. That is a very different matter from merely laying muscle, even if it is a flap of viable muscle, over a bronchial opening.

I think Doctor Wangenstein's suggestion in regard to chronic empyema is an excellent one, having very distinct merits, and again it serves, somewhat, to accomplish the closure of bronchial fistulae by a certain amount of mobilization of the lung which permits circular contraction.

I want to say a word or two also about Doctor Speed's paper on tumors of the chest wall. I think it is very essential in a paper of this sort before

a group of general surgeons, to mention that there is very great, immediate danger present in operating upon these tumors of the chest wall. Certainly no one should undertake an operation upon one of these tumors without being prepared to use intratracheal anesthesia, if necessary, in order to save the patient. It is quite true that in some cases one can remove the entire side of the chest wall without any special precautions to maintain the intrathoracic pressure, but those instances are great exceptions.

Again, there is another feature about these tumors that I should like to mention as a warning, and that is that one can never be quite certain from the roentgenologic appearance about how large the tumor actually is. Some of these tumors, which contain a minimal amount of cartilage and bone and more or less soft tissue, may have such tremendous extensions inside the chest wall that one is amazed when the chest is opened to find that the tumor is considerably larger than he had anticipated before undertaking the operation. For example, at the present moment I have a patient who had a tumor of undiagnosed nature before I operated upon him, a tumor which cast only a very faint shadow. To my amazement, when I opened into the chest I found a large lipoma of the pleura, projecting into the pleural cavity. This is a very rare tumor, by the way. It was necessary to make an exceedingly wide opening in the chest wall and to remove a very considerable amount of parietal pleura with the tumor, as it was so firmly attached to the pleura that it could not be separated. It would have been an easy mistake to have concluded, before the operation, that the removal of the tumor would be simple. Such was certainly not the case.

Again, there are other tumors to which reference should be made, namely, the group of neurofibromata, von Recklinghausen's disease, which sometimes occur along along the intercostal nerve, but yet may be connected with portions of the tumor, which may arise really within the vertebral column; tumors of the type which Doctor Heuer and Dr. Andrus discussed a few years ago under the name of hour-glass tumors. I have a patient with such a tumor in the hospital now, a young woman with an enormous intercostal neurofibroma, which involved the entire intercostal nerve. There was no indication from the external appearance, or from the roentgenographic appearance either, for that matter, of the enormous extent of this tumor.

DR. ARNOLD SCHWYZER (St. Paul, Minn.).—Showed several lantern slides of a case of an endothelioma of the pleura upon whom he had operated, as complementary to Doctor Speed's presentation, and cited the appended case report.

Case Report.—Male, aged 23, student. In January, 1929, he began to have pain in the lower right side of his chest anteriorly. A roentgenogram showed a lobulated mass with a pedicle attached to the right pleura. It was thought to be either an encapsulated serous pleurisy or a cyst. It was tapped and 10 cc. of a straw-colored fluid were removed which proved to be negative when cultured. The patient then felt somewhat better.

On May 9 and June 15, 1929, roentgenograms were taken but showed no change in the shadow. He then went away and was not seen until November, 1929, at which time he complained of a swelling over the right lower chest and also severe pain. The roentgenogram taken at this time showed that the mass had grown considerably and the diagnosis was then made of probable endothelioma of the pleura at the right base. Tapping yielded 5 cc. of fluid. A tuberculin test was negative. On December 22, 1929, a biopsy established the diagnosis of endothelioma. It did not seem very malignant according to the microscopic picture. The case was referred to me January, 1930.

Though endothelioma of the pleura is usually a far spread condition, we had here an

apparently localized tumor. If nothing were done there would be a long period of desperate hopelessness before the patient, with Death steadily stalking closer toward him. The tumor was so clearly outlined toward the lung, though reaching far inward, that we thought possibly it had not invaded it, though the attachment to the diaphragm made this doubtful. We figured that in case the tumor had no attachment the outlook was quite reassuring, but if it were firmly adherent to or had grown into the lung, a clean resection of the adjoining lung was possible. The degree of extension into the diaphragm was uncertain, but with a wide and sufficient opening we could perhaps cleanly resect this area. There was nothing discovered elsewhere in the body to indicate that this tumor was perhaps secondary, as tumors of the pleura often are. There had been no previous operations for apparently minor skin or other growths. The pleura, apart from the tumor, seemed entirely normal.

A very simple overpressure apparatus was constructed by attaching two intranasal tubes to an oxygen tank with a tapping sidewise for control of the pressure. This consisted of a rubber tube from which a glass tube entered for 20 cm. into a deep basin filled with water. Thus the pressure was regulated.¹

Operation.—January 8, 1930. After an hypodermic of 1/6 gr. of morphine and 1/150 gr. of atropine, 2 cc. of spinocaine was injected into the spinal canal. We use a little modification of Pitkin's method in that we turn the patient onto the stomach immediately after the injection and make use of the dorsal curve of the spine to allow the solution to rise to the desired height. This works admirably and has been adopted by several of my St. Joseph's Hospital colleagues. The anesthesia was perfect and the patient in good condition throughout the operation apart from some transient nausea. An incision, about 14 cm. long, was made parallel with the ribs, and included the scar of the biopsy incision. The sixth rib was removed for a length of about 12 cm., and the mass could now be better appreciated. It seemed rather intimately connected with, and directly under, the seventh rib. The seventh and eighth ribs were divided anteriorly and posteriorly and allowed to remain attached to the growth. A small opening in the pleura allowed air to enter slowly. Overpressure was installed from an oxygen tank. The respiration was very quiet, though the lung was allowed to become considerably collapsed. The patient's color was very good and remained so. The usual coughing spell on interfering with the pleura did not occur. The pleura was then widely opened; the lung was nowhere adherent and its surface as well as the parietal pleura was perfectly normal. On lifting the rib with the tumor the attachment to the diaphragm tore loose. All the intercostal structures including the pleura from the sixth to the eighth rib were removed in one piece. There was only a very superficial involvement of the diaphragm, and an area about 3 cm. in diameter, near the periphery of the diaphragm anteriorly, was excised and the defect closed with catgut. Closure of the wound was effected by suture of the extracostal muscles with continuous catgut. Before pulling the last suture through, the patient was requested to strain and thus empty his pneumothorax. Air tight continuous skin sutures of linen were introduced.

Recovery was smooth. Patient was out of bed four days after the operation, feeling well. By February 17 he had gained ten pounds. The postoperative exudate absorbed rapidly.

Radium was applied to the chest in considerable quantity. Up to the end of 1930 he had had about 13,000 milligram hours, filtered by 1 Mm. of lead and 12 Mm. of wood.

On October 2, 1930, the entry was made, "Patient looks very well, weighing more than ever before; says he feels perfect." Roentgenologic examination showed a normal lung field on the operated side, but a haziness in the left lung field suggestive of some thickening of the pleura.

On January 8, 1931 (one year to the day after the operation), the patient suddenly felt a sharp pain in the left side which persisted several days. A similar attack occurred in February and a third in March, at which time he returned to the hospital. An involvement of the left side was apparent. By June dyspnea became severe and the whole

left side was dull. Two attempts were made to obtain fluid, with negative results, though the left side bulged markedly. A nodule in the left supraclavicular space was then noticed which had grown to the size of a lemon at the time of death, August 26, 1931.

Autopsy.—(University Department of Pathology.) The right pleura and the right diaphragm were found to be normal. There was no evidence of any involvement of the right diaphragm. At the bottom of the right lower lobe there was a small nodule and another on its anterior surface. No pleural adhesions were noted. The left pleura was intimately adherent to the lung and diaphragm. The left lung consisted entirely of white rounded tumors varying in size from three to eight centimeters in diameter. The mediastinum did not appear invaded. Metastases had occurred to the ligamentum teres hepatis and to the periaortic and cervical lymph nodes. Microscopically the lung showed endothelioma.

Neither Sauerbruch nor Lilienthal report an operation for endothelioma of the pleura in their books on Surgery of the Chest. Endotheliomata, which hold a position midway between connective tissue tumors and carcinomata have important clinical characteristics. They differ from sarcomata and carcinomata by their slower growth and by the fact that they usually do not produce metastases until late, when the tumor has reached a considerable size. The neighboring lymph channels are not invaded early, as is usual in carcinoma. The prognosis is better, therefore, after thorough removal. However, they are known to be exceptionally prone to recur locally, much more so and earlier than carcinomata.

Whether in this instance the two aspirations and the biopsy had an influence on the spreading of the neoplasm is problematical. It is, however, of interest that even one year after the appearance of the first symptoms the operation furnished a local cure.

REFERENCE

¹ Schwyzer, Arnold: Notes of Surgery of the Mediastinum. *ANNALS OF SURGERY*, 75, 53.

DR. EUGENE H. POOL (New York, N. Y.).—In connection with Doctor Graham's remarks, it is true that a few years ago, with Doctor Garlock, I reported a method of a pedicle muscle flap for the closure of a bronchial fistula. Subsequently we found that this method had already been published in a foreign journal, so we can lay no claim to originality. It is, however, an extremely satisfactory one and has been used in an appreciable number of cases with success.

DR. JOHN ALEXANDER (Ann Arbor, Michigan) closing.—Doctor Lilienthal brings up a point he made a number of years ago, that in performing a secondary thoracoplasty—that is, revising a thoracoplasty which had been badly performed before—it is perfectly possible to resect the anterior portions of the ribs by reopening the posterior incision, resecting the regenerated ribs posteriorly and carrying the resections much farther forward than they were carried previously. The point I wish especially to make is not in regard to a secondary thoracoplasty but in regard to the horizontal staging of the primary thoracoplasty.

By this I mean that only exceptionally should the resection of the ribs be carried as far forward as their costochondral junctions during a posterior thoracoplasty operation. If additional collapse should be needed the anterior portions of the ribs and the cartilages may be dealt with in a number of ways, thereby horizontally staging the costal resections and preventing too sudden pulmonary collapse and undue paradoxical respiratory motion.

Since permanent anterolateral mobility may prove to be harmful to the tuberculous lesions, as well as to respiratory functions, the periosteum of the

ribs that have been removed should be rubbed with 10 per cent formalin only from the vertebrae to approximately the posterior axillary line, where the rigid scapula prevents undue movement of the decostalized thoracic wall. In cases in which the pleura is relatively rigid and in which it is important that prolonged contraction of the diseased lung, or an empyema cavity, should not be prevented by costal regeneration, all the periosteum of the resected ribs should be formalinized.

After having used electrocoagulation of vessels for approximately two years I abandoned it because occasionally a reactionary hemorrhage and hematoma occurred in spite of the wound having been left perfectly dry at the conclusion of the operation.

In removal of large tumors of the thoracic wall I should like to suggest the use of the Drinker Respirator in cases in which great postoperative paradoxical movement results in anoxemia and impending cardiorespiratory decompensation. The Respirator can be regulated so as to compel the decostalized portion of the thoracic wall to move outward during inspiration, instead of inward as in paradoxical respiration. Some years ago, before the Respirator was available, I lost a tumor patient from paradoxical respiration who, I believe, would have been saved by its use. Several years ago a patient, in whom death was imminent from great paradoxical movement following the third stage of a thoracoplasty, was dramatically saved by being placed in the Respirator. As I recall, the pulse rate dropped from 160 to 110 within 15 minutes. Since cardiorespiratory compensation gradually developed within a day or two, the patient needed to be in the machine only intermittently for several additional days.

DR. KELLOGG SPEED (Chicago, Ill.) closing.—In response to Doctor Tinker's prompting, may I say that the patient with the large tumor of the chest wall, with the resection of the abdominal wall, the liver and the diaphragm, has since borne four children. She is robust and weighs 210 pounds at the present time. She has recently had an hysterectomy and assures me that there will be no more children.

Doctor Harrington's illustrations show the technical difficulties of removing some of these tumors in their advanced stage. When they become myxomatous and infiltrating, they may invade the pleura or the lung to a certain extent, and it is not easy to lift them away from the lung. It is somewhat of a comfort if, on opening the chest, one sees the lung collapse away, following which radical excision may be performed; but if the pleura is infiltrated and the lung is adherent, the procedure may not be possible, that is, the decortication and removal of the surface may not be possible at that one sitting. Doctor Schwyzer's case is perhaps another instance showing the necessity of being sure about primary and secondary tumors. For that reason, I should like to stress again my remark that any tumor of the thoracic wall warrants removal, or a very thorough investigation.

DR. NORMAN S. SHENSTONE (Toronto, Canada) closing.—In regard to Doctor Lilienthal's question, this was a septic abscess containing all of the various putrefactive organisms found in the mouth, and with foul expectoration. It was, however, a chronic abscess and therefore had a smooth wall.

I had not seen the use of intercostal muscle taken some distance from the fistula itself described before, but make no claim of originality in using this procedure. In a very large proportion of cases that I have seen with fistulae of this sort, the ordinary muscles of the chest wall have been so widely destroyed that it has been quite impossible to obtain muscle tissue from the usual superficial sources.

TRAUMATIC SURGERY OF THE LUNGS AND PLEURA

ANALYSIS OF 1,009 CASES OF PENETRATING WOUNDS

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DURING the 14 years from 1922 to 1935 there were admitted to the Emory University Division (for Negroes) of the Grady Hospital of Atlanta (municipal) 1,187 patients suffering from wounds of the chest. Of these injuries 1,009 (85 per cent) were diagnosed as penetrating the lungs or pleura, and 162 (15 per cent) were diagnosed as nonpenetrating. In addition, 16 cases of stab wound of the heart and one case of stab wound of the pericardium were sutured, with a recovery of 50 per cent. The possibility of cardiac damage should be considered in every patient with thoracic trauma.¹ Many of the fatal injuries of the lungs and pleura also included wounds of the heart and great blood vessels which were not diagnosed or treated. The proportion of male to female patients was three to one, the average age being 27.

The majority of these patients apparently had small wounds of the lungs or pleura caused by slender, sharp pointed weapons such as an ice-pick or "swish-blade," four inches long, so called because the assailant "swishes" the knife open to stab his victim. Care was exercised in determining which of these cases were penetrating and which were nonpenetrating injuries, although in a considerable number it was difficult, if not impossible, to tell the difference. This especially was true when the clinical and roentgenologic findings did not agree, as in the following case:

Case 1.—A Negro boy was stabbed in the right fifth intercostal space, anterior axillary line, and was brought immediately to the hospital. A definite sucking wound was present, and was sutured. The patient had some pain and dyspnea. On admission the pulse, temperature and blood count were normal, but 24 hours later the pulse rose to 120, and temperature to 103° F. Respiration was 24 on admission, but the next day was 32. The wound was not infected. There was some lagging in breathing on the right side; the chest below the wound was tympanitic, with decrease in breath sounds; tactile fremitus was unchanged. Cellular emphysema was absent. The morning after admission, dulness was present in the right chest over the lower ribs in the postaxillary line, and it was thought that a penetrating wound existed, possibly with hemopneumathorax. The roentgenologic report the following day revealed no evidence of pneumathorax or hemothorax. The patient later developed a cough, but had no bloody expectoration. His condition improved constantly, the temperature reaching normal on the fifth day. Treatment consisted in bed rest, care of the wound, cough medicine and two hypodermics of morphia. Dismissal on the tenth day, apparently well. The final diagnosis was penetrating wound of the chest, with hemopneumathorax too small to be detected by roentgenology.

Causes of Penetrating Wounds.—Of the 1,009 cases of penetrating wounds, 799 (79 per cent) were stab wounds, and 207 (21 per cent) were

gunshot wounds. Two patients were injured in automobile accidents, and one by a falling roof. This class of patients is not so subjected to automobile accidents as white patients. Injuries from automobile accidents are more likely to be nonpenetrating than penetrating, but it is well to recognize the fact that the same kind and same extent of injuries may take place in wounds which do not penetrate the thoracic cavity as in those which produce penetration. Fatal damage may occur to the lungs or pleura by concussion or compression without a penetrating wound. However, the possible presence of open pneumothorax in a penetrating wound increases the gravity of the prognosis in such cases.

Signs and Symptoms.—In the average patient with penetration, the injury was accompanied by more or less pain, followed by weakness, and in severe cases by shock. The majority of the patients reached the hospital within an hour or two after being hurt, although a delay of three days is recorded in one case. Insistent persuasion sometimes is necessary to induce sick Negroes to enter the hospital, that is, those with appendicitis or intestinal obstruction, or afflicted with various medical disorders; but those with trauma, such as fractures and gunshot wounds, usually come voluntarily. Another characteristic of Negro patients is noticed in their apparent indifference to traumatic lesions as compared with their apprehension in mysterious internal maladies. Such lack of psychic reaction probably is an important factor in the favorable results obtained in chest injuries.

Cough and hemoptysis in the average patient were signs of uncertain value. Their absence was not regarded as significant. Sometimes there was a history of expectorating a considerable amount of blood immediately after the injury, which did not appear again. Hemoptysis does not necessarily indicate laceration of lung tissue, nor is it a constant sign of the lesion. Hemoptysis rarely is fatal unless one of the large blood vessels of the hilus is ruptured, and there is direct communication between a bronchus and the vessel, or unless there is extensive laceration of a lung which is unable to collapse on account of adhesions.

Dyspnea generally was present to a greater or less extent. Marked distress in breathing usually meant pneumothorax or hemothorax. In the early stages of the typical case two characteristic signs of penetrating wounds are lagging of the affected side on respiration, and the presence of moist râles in the area involved. As a rule increased pulse and respiratory rate, fever and leukocytosis were present from the beginning, although mild cases might barely show such signs. Decreased resonance and diminished breath sounds were noted until the presence of air caused increased resonance or the presence of fluid caused dullness. Cyanosis is difficult to recognize in these patients.

Pneumothorax, Hemothorax, Hemopneumothorax.—Pneumothorax was diagnosed in 193 cases (19 per cent); hemothorax in 248 cases (25 per cent); hemopneumothorax in 382 (38 per cent); and none of the above in the remaining 18 per cent. It is probable that hemopneumothorax was present

in even a larger percentage of cases than is indicated. Sometimes the amount of air was enough to cause complete pulmonary collapse, while in one case as much as 2,700 cc. of bloody fluid was aspirated in one sitting. The largest total amount of fluid removed in one patient was 10,900 cc., taken in quantities from 500 to 1,400 cc. over a period of five weeks. The extent of air or blood present may be limited by preexisting pleural adhesions.

The signs and symptoms of hemopneumothorax resemble those of hydrothorax, with certain differences. In the former dyspnea almost always is present, and is intense. The accumulation and absorption of the blood in some cases were responsible for a rise of temperature as high as 103° F. This evidently was a so called aseptic fever as proved by its subsidence upon withdrawing the blood. Occasionally the dulness and resistance in hemopneumothorax were not so pronounced as one would expect with the displacement of the heart and the dyspnea. Such lack of dulness and resistance was supposed to depend upon the mixing of air with the blood. Air was aspirated in nine of the cases in the series, and blood was aspirated in 185 cases (18 per cent).

Roentgenologic Evidence.—Often the first roentgenologic evidence of penetration was slight elevation of the diaphragm on the affected side. It is interesting that this sign should exist even with a large hemothorax, the weight of which should lower the level of the diaphragm. Two explanations for the phenomenon have been offered,² one being that the phrenic nerve, which is comparatively unsupported in its passage through the thorax, is particularly susceptible to the concussion produced by the injury, and that paralysis of the nerve permits the elevation. The other suggestive explanation is that the collapse of the lung following the impact of the foreign body causes at first a considerable negative intrapleural pressure. The fluoroscopic view and roentgenogram are of indispensable aid in studying thoracic injuries. They are always correct, but sometimes we read in them things which are not there, or do not read things which are present.

Infection.—Various authors and text-books continue to list infection as a common complication of penetrating wounds of the lungs and pleura. Possibly war wounds are meant. Infection was extremely rare in this series. There were only 17 cases of empyema, with six deaths, and no instances of pulmonary abscess or gangrene. Eight cases of pneumonia were reported, with five deaths. Some wounds of the chest wall became infected, but seldom with serious results. Infection in such wounds and in wounds in other parts of the body were far commoner than infection in the pleura. The pleura seems to be endowed with as effective resistance against ordinary infection as the peritoneum.

Cellular Emphysema and Sucking Wounds.—Cellular emphysema was noted in 159 cases (15 per cent). Sometimes there was only a small amount of air in the tissues about the chest wound; again most of the chest wall, axilla and neck were involved. Emphysema does not necessarily indicate penetration, and the same may be said of the so called sucking wound. Air

from the outside may enter the tissues through a wound in any part of the body, but particularly the thick muscular tissues of the chest wall, on account of the suction action of the movements of respiration. Likewise a non-penetrating wound of the chest wall may furnish the appearance and sound of a sucking wound due to communication with the pleural cavity.

Treatment.—The treatment of the majority of patients was simple, consisting of sterilization of the wound, or wounds, with débridement if indicated, bed rest, and the administration of ample sedatives. Usually the chest was strapped, but if the patient objected, strapping was omitted, even if ribs were fractured—a rare complication. Sucking wounds were sutured immediately. The majority of the patients received tetanus and gas bacillus antitoxin. No case of tetanus or gas bacillus infection developed.

The administration of saline solution and glucose subcutaneously or intravenously as routine treatment in all but the mildest cases has proved of material assistance in overcoming shock and hastening convalescence. Formerly it was difficult to obtain donors for blood transfusion in Negroes, but since they have learned that no harm comes to the donor, the transfusion is performed far more frequently, and is especially valuable in patients with recurring hemothorax.

The most serious consequence of thoracic trauma is hemorrhage. Fortunately the blood pressure in the pulmonary system is lower than that in the general circulation, and pulmonary blood is said to clot more readily; otherwise death from hemorrhage would result in a larger number of the cases. Believing that the presence of air and blood in the pleural cavity acts as an effective tamponade against further bleeding, it has become a rule in the Grady Hospital not to aspirate blood during the first 48 hours after the injury, unless the patient complains of distressing pain or dyspnea.

Rupture of the blood vessels of the thoracic wall calls for prompt ligation. Such hemorrhage occurring externally is easily recognized, but bleeding into the pleural cavity may be mistaken for pulmonary hemorrhage. In this series there were five ligations of an intercostal artery, with two recoveries, and two ligations of the internal mammary artery, without recovery. Exploratory thoracotomy for pulmonary hemorrhage was done once, with failure to save the patient. Some form of interruption of the phrenic nerve to elevate the diaphragm has been suggested by Warner³ as an aid in controlling intrathoracic bleeding.

So few operative procedures were employed in this large group of chest injuries that the series almost falls into the category of medical rather than surgical cases. The results, however, appear to justify such conservative treatment. It is admitted that a few of the fatalities in this record might have been avoided by early thoracotomy. The danger in protracted satisfactory results in the nonoperative treatment is that when a case is presented which calls for radical management, the different situation is not realized, or realization comes too late.

Blood was aspirated, under the rules mentioned, in 185 cases (18 per

cent); air was aspirated in nine cases. The diaphragm was sutured in 18 cases, with ten recoveries. It was not feasible to suture the diaphragm in one instance, on account of the patient's weak condition. He finally was discharged as improved, with a potential diaphragmatic hernia.

Mortality.—The total number of deaths among the 1,009 cases was 136 (13 per cent), gunshot wounds proving more fatal. Deducting the patients who died of irremediable trauma within the first 24 hours after admission, 46, the deaths numbered 90, a mortality rate of 9 per cent. Fifty patients came in with associated injuries of the abdomen, kidneys, spinal cord and other viscera, which contributed to the fatal result. Deducting this number leaves 86 patients whose demise was attributed solely to chest injury, a mortality of 8.5 per cent.

End-results.—In this class of patients a follow up system is practically impossible. When they leave the hospital they are requested to return to the outpatient clinic for observation, but very few ever return. It is difficult to locate them at home since they constantly move and change their names. Many of the patients owe their injury to law breaking, and they do not care to coöperate in a follow up system. They fear the police are still on their trail. In spite of so many patients being discharged as well or improved, no doubt an investigation of the end-results would reveal crippling permanent disabilities from pleural adhesions and other factors.

Summaries of two typical bad cases are submitted, with roentgenographic illustrations:

CASE REPORTS

Case 2.—Male, aged 27, admitted to the hospital August 5, 1935. Two or three hours previously he had received a stab wound in the upper left chest anteriorly, accompanied by considerable pain and a large amount of bleeding. When first seen in the ward he was suffering from respiratory distress and mild shock. Pulse on admission was 90, temperature 97.3° and respiration 24. Emphysema was present at the base of the neck and in the upper part of the chest. There were lagging respiration on the affected side, and diminished breath sounds. The next day the pulse was 120, temperature 101°, the respiratory note remaining about the same throughout sojourn in the hospital. The pulse did not go any higher, and the temperature ranged between 99° and 103° and 104° during four months' hospitalization. The leukocyte count was normal except in the beginning of empyema, when it rose to 14,000. Dulness soon developed in the left side, and the roentgenogram three days following admission indicated fluid forming. Four weeks later aspiration withdrew 100 cc. of serosanguinous fluid. The patient was given 500 cc. of blood by transfusion, and a week later rib resection was performed, and 800 cc. of thick pus were removed. He was dismissed as improved.

Case 3.—An example of a patient admitted to the outpatient clinic for suture of an apparently mild injury of the chest wall, allowed to go home, and having to enter the hospital ten days later on account of weakness, bleeding and shortness of breath. He was 31 years old, and when first seen had to sit up in bed on account of dyspnea. Expansion was limited on the affected side, the percussion note was dull, and there was absence of tactile fremitus. He was admitted May 8, 1935, and two days later the roentgenogram disclosed hemothorax of the left chest with complete displacement of the mediastinal contents to the right. The same day 1,000 cc. of bloody fluid were

WOUNDS OF LUNG AND PLEURA

aspirated, and specimen sent to laboratory for culture, which at this time was negative. However, the patient's temperature ran a septic course until death, after 48 days. The total quantity of fluid aspirated in five weeks was 10,900 cc., in amounts from 500 to



FIG. 1.—Case 2.—First Film. Showing uniform increased density over lower two-thirds left chest, with fluid level rising in the axilla and over the apex. No fluid level to suggest pneumothorax. Heart not displaced. Impression: hydro- or hemothorax left chest.

FIG. 2.—Case 2.—Second Film. Showing pyopneumothorax left chest, with fluid level opposite seventh intercostal space in scapula line. Left lung collapsed, heart displaced to right. Drainage tube in fluid space.

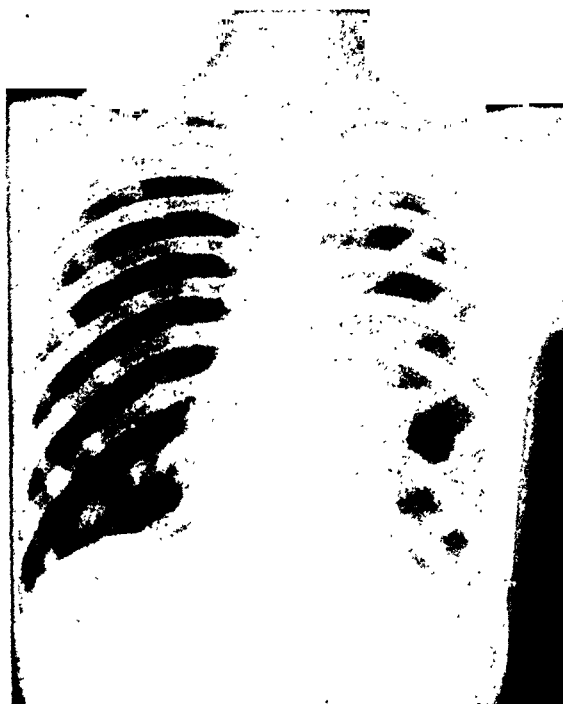


FIG. 3.—Case 2.—Third Film. Showing pneumothorax left chest, with about 60 per cent lung collapsed. Ninth left rib has been resected in posterior axillary line. Parietal pleura thickened, heart still displaced to right. Small amount of fluid still present. Impression: postoperative empyema. Patient recovered.

1,400 cc. The character of the fluid gradually changed from blood to pus. The patient was given one blood transfusion three days after entering the hospital. Rib resection for empyema was performed five weeks later. An early thoracotomy for checking hemorrhage might have offered the patient a better chance.



FIG. 4.—Case 3.—First Film. Showing hemothorax, with complete displacement of heart to right. Note displacement of trachea.

FIG. 5.—Case 3.—Second Film. Showing hemothorax, with fluid level extending to third interspace anteriorly. Pneumothorax above fluid level. Heart displaced to right. Total of 10,900 cc. of fluid removed at different aspirations. Patient died.

SUMMARY AND CONCLUSIONS

Penetrating wounds of the lungs and pleura may exist with so little pneumothorax or hemothorax as not to be demonstrable in the roentgenogram. Empyema and other serious infections result in less than 2 per cent of the cases. Hemorrhage is the commonest cause of death. The chest wall should be examined for bleeding. Pain and dyspnea are relieved by withdrawing blood and air, but intrathoracic hemorrhage may be controlled by deferring aspiration for 48 hours. The nonoperative treatment of the ordinary cases encountered in civil practice gives a low mortality rate, but in a few cases radical surgery is urgently indicated. The total mortality rate in 1,009 cases was 13 per cent; deducting the patients who died in the first 24 hours, the rate was 9 per cent; deducting the patients who had associated injuries which contributed to their deaths, the rate was 8.5 per cent. The final effects of these injuries should be studied.

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A TEN YEAR STUDY OF EMPYEMA IN CHILDREN

1926-1936

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EMPYEMA as a surgical disease has been of great interest to the surgeon for many years. The greatest progress in the management and refinement of technic has been evolved since the initial work of the Empyema Commission¹ which was established by the Surgeon General of the Army in 1918. The basic principles as emphasized by this Commission still form the foundation of our present day therapy.

In the hope of lowering the mortality of this disease many and varied details of treatment have been advocated by numerous authors. The principle of avoiding the creation of an open pneumothorax in the formative stage of an empyema is fundamental and is now a universally accepted fact. There is a present day trend in advocating open drainage over all other methods when the empyema is a true abscess. This procedure is founded on the experience of many surgeons^{2, 3, 6} as meeting the most satisfactory requirements of producing good results.

The studies herein reported include a method of surgical drainage which combines the principles of closed and open drainage. They also include a classification of the type of pneumonia preceding the empyema and the incidence of the latter. Being impressed by the studies of Heuer,⁴ Graham and Berck² in which they noted a parallelism of the mortality of pneumonia and empyema, we were led to review our records in this light.

In the ten year period 1926 to 1936, 5,868 patients were classified as pneumonia, and of this number 407 or 0.7 per cent developed empyema as a complication which required surgical drainage. In this series a similar parallelism has been found as previously reported by the above authors and lends further support to the idea expressed that the type or virulence of the pneumonia preceding the empyema is the most important factor in determining the mortality rate of empyema in a given series treated over a period of years. It is interesting to note in this ten year period that empyema occurred as a complication in 8.9 per cent of the patients classified as lobar pneumonia and in only 1.2 per cent of those classified as bronchopneumonia (Chart 1).

The mortality of lobar pneumonia for this period was 14.3 per cent, while that of bronchopneumonia was 44.5 per cent (Chart 2).

Another point of interest is that the highest mortality of empyema in St. Louis is reported by Graham in 1926, while that reported by Heuer from Cincinnati was highest in 1927, and in Detroit our highest mortality was in 1929 (Chart 3).

This observation shows that the same disease has a different mortality in spite of the fact that the treatment was a uniform procedure in these different cities. This may be explained by the variance of virulence of the epidemic of the preceding pneumonia in relation to geographic location.

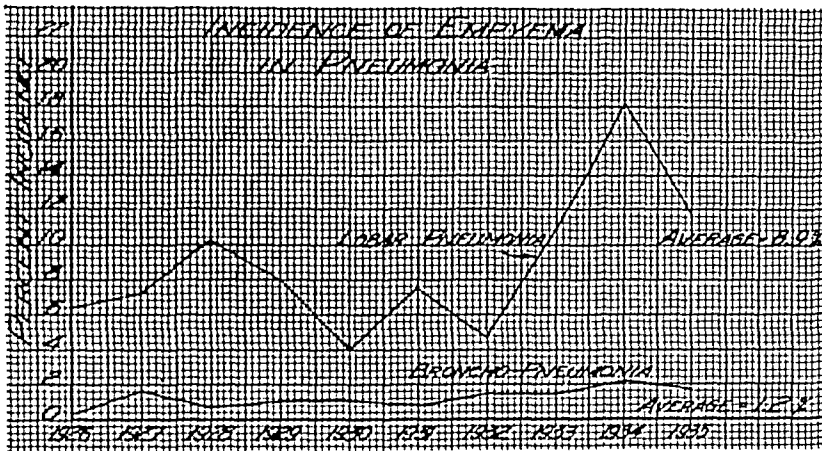


CHART 1.—Incidence of empyema in pneumonia by year periods.

A uniform procedure of treatment has been practiced in the surgical drainage of these cases consisting of aspiration up to the stage when frank pus is obtained. At this time the trocar-cannula-catheter method of closed drainage is instituted under local anesthesia. Closed drainage is maintained by apply-

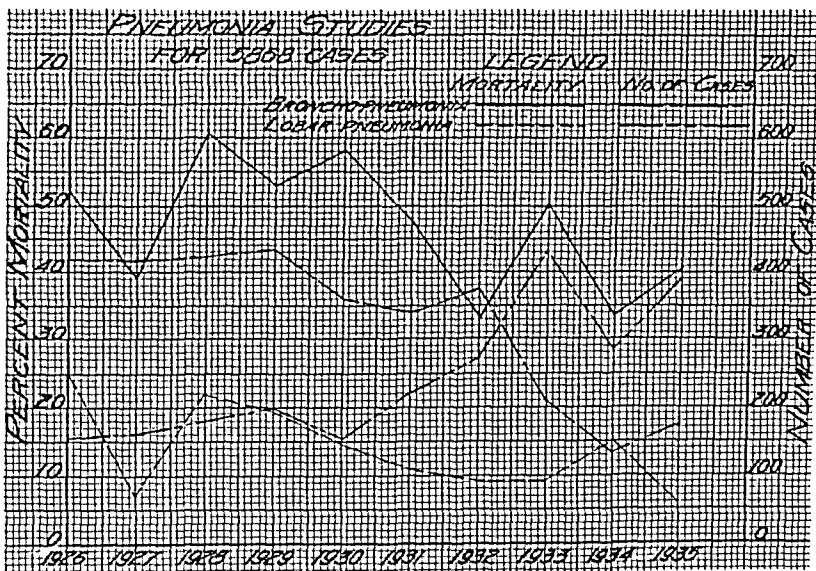


CHART 2.—Number and mortality rate of pneumonia by year periods.

ing a hemostat to the end of the catheter. The empyema cavity is aspirated in the operating room up to the point where reflex coughing or a small amount of blood-tinged pus appears in the fluid. The patient is then returned to the ward. There has not been any evidence of shock or circulatory or respiratory distress. Further aspirations are carried out every four hours by the house officers or graduate nurses trained in this technic. The majority of cases in the early years of this series were subsequently irrigated with 0.5 per cent

EMPHYEMA IN CHILDREN

sodium hypochlorite solution (Dakin's solution) following aspiration of the pus, but of late years, irrigations have been used less often with no material difference in the prolongation of the period of morbidity. It is observed, as reported by others,³ that with this type of closed drainage there may be some

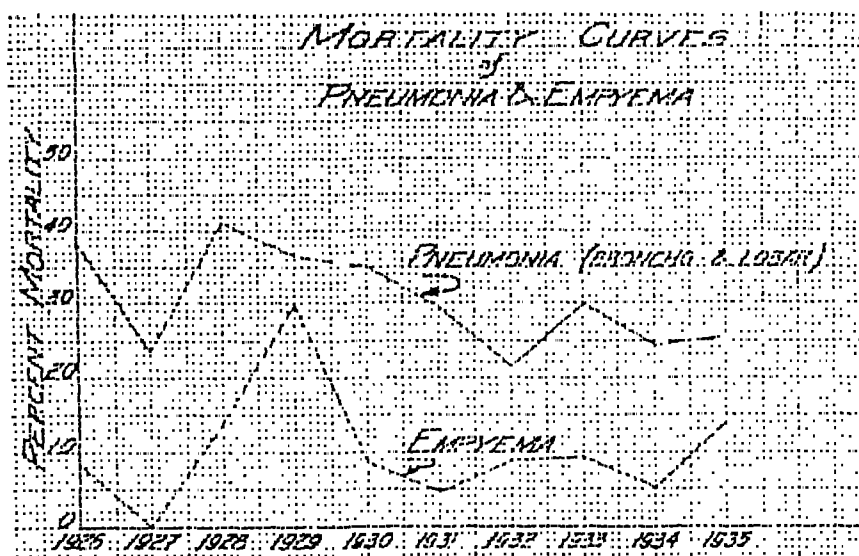


CHART 3.—Mortality curves of pneumonia and empyema by year periods.

leakage of pus around the tube, but this occurs at a time when the empyema cavity is practically empty and should be no cause for alarm or for the changing of the catheter. The original catheter is left in place usually 12 to 18 days, at which time it is cut and allowed to remain open as a drain. In the

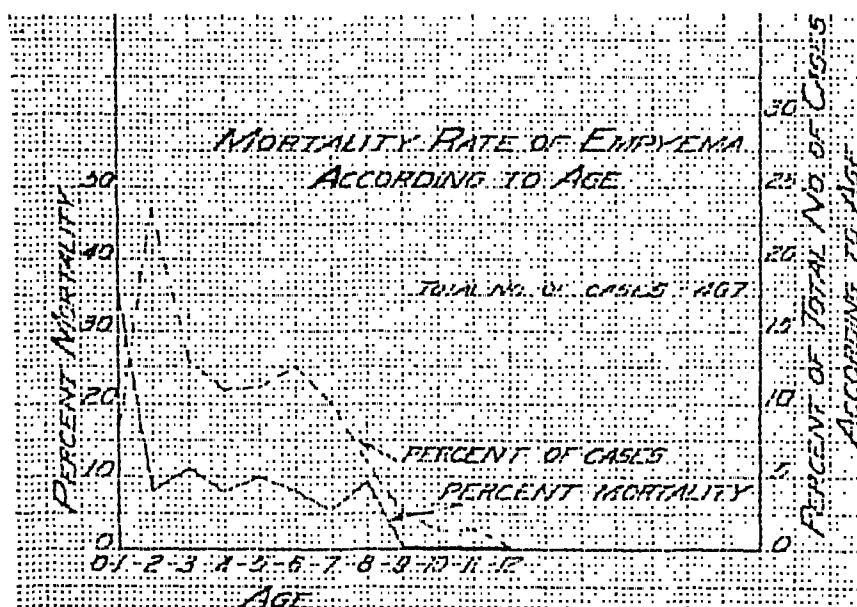


CHART 4.—Mortality rate of empyema according to age of patients.

event there is clinical evidence of retention, manifested by a rise in temperature or roentgenologic evidence of fluid, the catheter is replaced by a larger tube. It may be necessary to use local or nitrous oxide-oxygen anesthesia before inserting this larger tube. This lessens the mental trauma to a child who has been seriously ill. It has not been necessary in our experience to

resort to rib resection for adequate drainage following the procedures outlined except in the following instances:

- (1) Four patients developed recurrent empyema after the procedure described above who later made good recoveries.
- (2) Eleven other patients required rib resection with open drainage:
 - (a) In five patients the pus was too thick for a catheter drainage as initial treatment.
 - (b) Five infants (1926-1927)—reason not recorded.
 - (c) One—reason not recorded.

In this group of 15 patients the average mortality was 6.7 per cent (one death) and a mean period of morbidity of 78.9 days.

FACTORS INFLUENCING MORTALITY

(1) As previously emphasized, the mortality of empyema bears a definite relationship to the type or virulence of pneumonia preceding the empyema.

(2) The age of the patient, as statistics show, that the greatest mortality is in infants, two years or younger. This is shown also in this series. The mortality for the various age groups up to 12 years is shown in Chart 4, as is also the percentage of cases according to the age groups.

(3) Poor nutrition of the patient is an important factor in any given series.

FACTORS INFLUENCING MORBIDITY

The average hospital stay was 48.6 days (Chart 5).

This period of morbidity may appear unusually long where early treatment is instituted and carefully followed. It can be explained by certain definite factors, *viz*:



CHART 5.—Average hospital stay of patients by year periods.

- (1) Many of these patients were admitted late in the stage of their illness.
- (2) The nutritional status of most of these patients entering this hospital is below normal and their apparent reaction to their infection is impaired.
- (3) The virulence of the organism.
- (4) Multiple encapsulations.
- (5) Complications such as otitis media, mastoiditis, bronchial fistula, *etc*.

(6) It has been the practice to observe the patient in the hospital for at least five days after the removal of the tube. Experience has shown that the patient who is sent home with a discharging sinus is frequently readmitted to the hospital because of a reaccumulation of fluid. An additional five day period in the majority of cases is established as an added precaution before discharge because of the poor home conditions of many. No patient has been discharged until the temperature remains normal, the roentgenologic check-up shows no fluid, or pneumathorax, and the sinus is free from drainage.

(7) In those patients with a large pneumathorax persisting after removal of the pus and in whom reexpansion of the lung has been slow, we have materially shortened the period of morbidity in the past two years by applying the Wangenstein⁵ method of suction.

END-RESULTS

Four hundred seven patients were treated by a combined form of closed and open method of surgical drainage with an average mortality of 10.3 per cent (Chart 6).

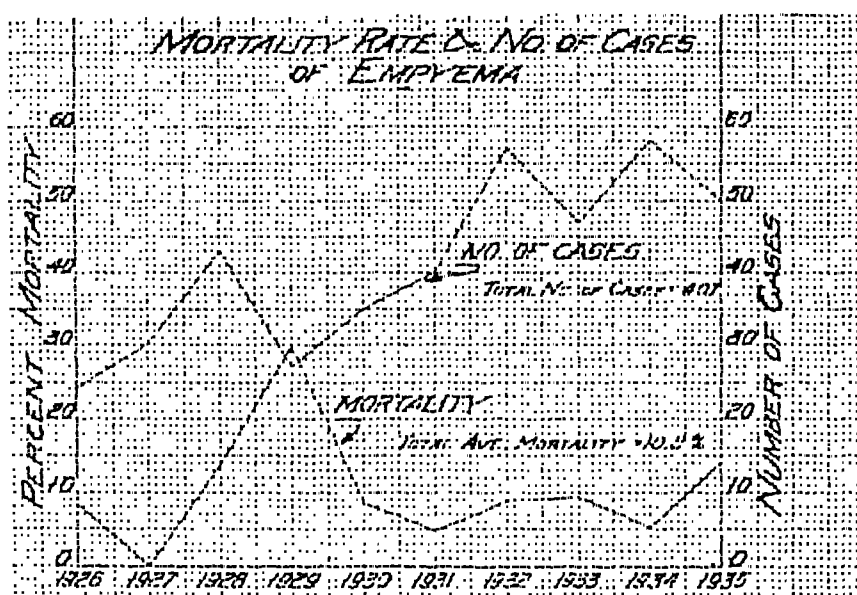


CHART 6.—The mortality curves of pneumonia and empyema by year periods.

Of the 365 patients who survived, all were clinically cured of the empyema except three. The latter required major operative intervention. One was classified as tuberculous empyema with a mixed infection, in whom closed drainage, followed by thoracoplasty in two stages, gave a good clinical end-result. One patient required an unroofing with a subsequent good result, while the remaining patient necessitated a decortication. The latter patient died 12 hours postoperative of surgical shock. Fifteen patients required rib resection and open drainage as previously described.

SUMMARY

- (1) A ten year review of pneumonia and empyema cases is reported.
- (2) There is a definite parallelism of the mortality of pneumonia and empyema.

(3) A uniform procedure of surgical drainage combining the closed and open technic is presented.

(4) Four hundred seven cases of empyema were treated by this procedure with an average mortality of 10.3 per cent.

(5) Of the 365 patients who survived, all but three made excellent clinical recoveries on discharge from the hospital.

(6) Fifteen patients required rib resection and open drainage.

(7) The average hospital stay of these patients was 48.6 per cent days.

(8) The Wangensteen method of suction offers a valuable aid in shortening the period of morbidity due to failure of the lung to reexpand after the surgical drainage of an empyema.

(9) Three patients required major surgical procedures for chronic empyema.

CONCLUSIONS

(1) The combined interest of the pediatrician, roentgenologist, and surgeon is important in the careful management of a child ill with empyema.

(2) Careful clinical and roentgenologic examination (anteroposterior and lateral positions).

(3) Aspiration for diagnostic (pus to be cultured) and therapeutic purposes up to the point of frank pus.

(4) The combined method of trocar-cannula-catheter drainage followed by open drainage is recommended.

(5) Attention to details which include blood transfusions as indicated, preservation of the normal water balance and nutritional status of the patient are essential to the successful management of a case of empyema.

We wish to express our thanks to the members of the medical department for their kind cooperation in this work and especially to Dr. Hira E. Branch for his valuable assistance in preparing the statistical data for this review.

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GASTRIC ACIDITY FOLLOWING OPERATIONS FOR GASTRIC AND DUODENAL ULCER

ITS EFFECT ON THE QUESTION OF PARTIAL GASTRECTOMY

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"GASTRIC ulcer and biliary disorders likewise present distinct regional differences—the part played by racial factors in these differences is as yet unknown to science." This statement recently appeared in a review of Schittenhelm's¹ work on the distribution of disease in Germany.

In 1930, after Snell and I had visited various surgical clinics abroad, particularly those in central Europe, we published a series of papers^{2, 3, 4, 5} describing and illustrating the difference between the lesions of duodenal ulcer for which we saw operations performed in Germany and those for which it has been my privilege to operate at The Mayo Clinic. This difference lay largely in the high degree of gastritis associated with duodenal ulcer of German patients operated upon at German surgical clinics, as compared with the low incidence of associated gastritis in a series of patients operated upon at The Mayo Clinic. Accuracy of these observations was confirmed by Sebening,^{6, 7} of Schmieden's Clinic (Frankfort am Main), who spent several months in study at The Mayo Clinic. More recently, in a clinical study, Church and I^{8, 9} showed that gastritis was a frequent accompaniment of pyloric obstruction. Dragstedt's¹⁰ experimental work confirmed our observations. Obviously, if gastritis is lacking to any great degree in a percentage of cases in which operation is performed for duodenal ulcer, gastritis cannot be considered an indication for subtotal or partial gastrectomy as a routine procedure in the treatment of duodenal ulcer. When I was discussing with von Haberer,¹¹ of Cologne, this difference of lesions accompanying duodenal ulcer, he made the interesting statement that in his experience as surgeon in Vienna, Graz, Dusseldorf, and Cologne, he found marked differences in the types of lesions encountered in these different areas. This was true even when such short distances separated the cities as that which lies between Dusseldorf and Cologne. These factors of so called geomedical variations may account, in part, for the difference in the results experienced in the treatment of different diseases in various countries, indeed, in different areas of the same country.

Concerning the surgical treatment of duodenal ulcer, it has been stated that ulceration does not recur after relative achlorhydria has been established and that failure to obtain relative achlorhydria following gastric resection for duodenal ulcer is attributable to the fact that an insufficient amount of

stomach has been removed. Although this was heard more frequently ten years ago than now, more recent experience of one group of investigators in the United States would indicate that relative achlorhydria occurred in but approximately 50 per cent of a series of 108 cases in which operation was performed in the clinic¹² where these investigators work. In this same reported series, nine cases of gastrojejunal ulcer developed in a group of 47 cases in which persistent relative achlorhydria was not established subsequent to subtotal gastrectomy.

In order to add further to knowledge of the effect of various operations for gastric and duodenal ulcer, studies of gastric acidity, using Töpfer's method, have been carried out in a group of approximately 150 cases encountered at The Mayo Clinic. In these cases, in the past year and one-half,

Mean and free acid before □ and after ▨ operation
155 cases 1-1-34 to 2-25-36

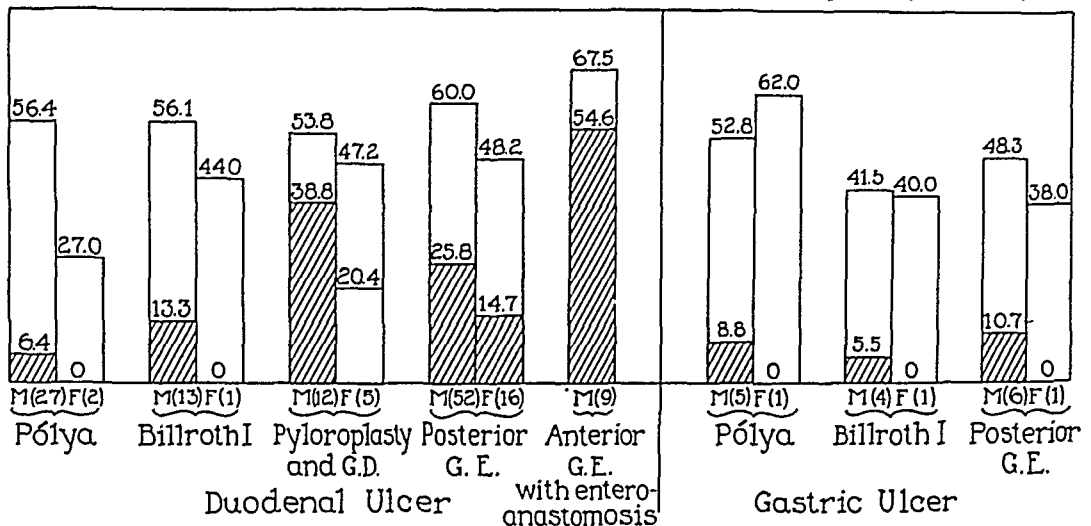


CHART 1.—Reduction of gastric acidity following various operations for gastric or duodenal ulcer.

I performed gastro-enterostomy, pyloroplasty, or gastric resection of the Billroth I or Pólya type for one or the other of the conditions named. Reduction in gastric acidity usually occurs following all of these procedures although most frequently, and to the greatest extent, following gastric resection of the posterior Pólya¹³ type (Chart 1). When anterior gastro-enterostomy is performed for duodenal ulcer, combined with entero-anastomosis, the latter preventing regurgitation of any great amount of duodenal and jejunal secretion into the stomach, very little reduction of gastric acidity takes place (Chart 1 and Table I). In an occasional case, when entero-anastomosis has been part of a gastric resection of the Balfour-Pólya type, similar lack of reduction in gastric acidity may occur. In many cases in which posterior gastro-enterostomy is performed for duodenal ulcer, gastric acidity will be reduced to the point of relative achlorhydria (Tables II and III). It would seem, therefore, that reduction of gastric acidity subsequent to posterior gastro-enterostomy and gastric resection of the Pólya type, in

POSTOPERATIVE GASTRIC ACIDITY

TABLE I

PARTIAL LOSS OF THE DILUTION OF GASTRIC ACIDITY WHEN ANTERIOR GASTRO-ENTEROSTOMY WITH ENTERO-ANASTOMOSIS IS PERFORMED FOR DUODENAL ULCER

Case	Age	Sex	Duration of Symptoms	Character of Ulcer	Acidity			
					Preoperative Total	Free HCl	Postoperative Total	Free HCl
1....	33	M.	15 Months	Subacute perforating	50	36	28	20
2....	52	M.	6 Months	Subacute perforating	98	90	82	70
3....	31	M.	12 Years	Subacute hemorrhagic perforating	62	46	60	44
4....	59	M.	3 Years	Subacute perforating	90	80	94	84
5....	65	M.	25 Years	Subacute perforating	58	46	74	56
6....	35	M.	15 Years	Hemorrhagic perforating	88	78	84	70
7....	56	M.	12 Years	Subacute perforating	92	84	60	50
8....	38	M.	25 Years	Multiple subacute perforating	60	50	50	38

many cases is the result of dilution of the gastric secretion by the fluids regurgitated from the attached jejunal loop. Further evidence of this is the fact that, in many cases in which achlorhydria seems to have occurred subsequent either to gastric resection or gastro-enterostomy for duodenal ulcer, acid gastric secretion can be obtained after injection of histamine.

TABLE II

RELATIVE ACHLORHYDRIA OCCURRING IN SOME CASES OF DUODENAL ULCER AFTER GASTRO-ENTEROSTOMY

Case	Age	Sex	Duration . of Symptoms	Character of Ulcer	Preoperative Acidity		Histamine Interval, Minutes								Postoperative Acidity	
					Total	Free HCl	10	20	30	40	50	60	70	Total	Free HCl	

1....	24	F.	3 Years	Subacute perforating with ob- struction	40	34									14	0
2....	38	M.	20 Years	Subacute perforating	62	50									12	0
3....	48	M.	12 Years	Subacute perforating obstructing	76	70										
							26	48	70	80	92	76	100		8	0
							16	42	62	74	86	70	96			
4....	35	M.	20 Years	Acute perforating	100	80									14	0
5....	47	M.	5 to 6 Years	Subacute perforating	118	100									10	0
6....	47	M.	35 Years	Chronic (?)	60	40									16	0

There are some cases, particularly after the Pólya type of resection, in which the histamine will not produce any response in gastric acidity. Further support for the belief that dilution plays an important part in reduction of gastric acidity following operative procedures for duodenal ulcer is the fact that when pyloroplasty has been performed, reflux of duodenal secretion is not active because of the onward normal peristaltic movement of fluids from the stomach through the duodenum and in such cases reduction in gastric acidity is obtained less frequently than when gastric resection or

TABLE III

RELATIVE ACHLORHYDRIA OCCURRING IN SOME CASES AFTER EXCISION OF
GASTRIC ULCER AND GASTRO-ENTEROSTOMY

Case	Age	Sex	Duration of Symptoms	Character of Ulcer	Preoperative		Acidity	
					Total	Free HCl	Total	Free HCl
1.....	46	M.	6 Years	Subacute	52	40	12, 12, 28, 28	0, 0, 0, 0
2.....	45	M.	18 Months	Chronic pyloric	80	70	16	8
3.....	43	M.	15 Years	Chronic (?)	72	60	8	0
4.....	48	F.	12 Years	Chronic (?)	50	38	8	0
5.....	38	F.	5 Years	Chronic	Not esti- mated	Not esti- mated	8	0
6.....	59	F.	1½ Months	Subacute perforating gastric and chronic duodenal	Not esti- mated	Not esti- mated	14	4
7.....	64	M.	20 Years	Subacute perforating	74	60	10, 12, 20	0, 0, 0
8.....	35	M.	7 Years	Subacute	36	26	4	0
9.....	64	M.	20 Years	Subacute perforating	74	60	10	0
10*....	42	M.	3 Years	Perforating	54	42	48	36

* Gastrojejunal ulcer developed.

gastro-enterostomy are performed. Similarly, even in cases in which extensive gastric resection has been performed for duodenal ulcer, and the end of the stomach has been sutured directly to the duodenum, the so called Billroth I von Haberer type of anastomosis (Table IV), the percentage of patients who will obtain relative achlorhydria is not great in proportion to those patients with duodenal ulcer who have been subjected to a Pólya type of anastomosis subsequent to gastric resection.

Gastric ulcer, on the other hand, apparently differs from duodenal ulcer, not only pathologically, but in its biologic response to the operative procedures mentioned in the preceding paragraph. Following gastric resection

TABLE IV

THE INFREQUENT OCCURRENCE OF RELATIVE ACHLORHYDRIA WHEN BILLROTH I-HABERER ANASTOMOSIS FOLLOWING PARTIAL GASTRECTOMY AND PARTIAL DUODENECTOMY IS PERFORMED FOR DUODENAL ULCER

Case	Age	Sex	Duration of Symptoms	Character of Ulcer	Acidity			
					Preoperative Total	Free HCl	Postoperative Total	Free HCl
1.....	49	M.	15 Years	Subacute perforating hemorrhagic duodenal	46	32	18	8
2.....	56	M.	8 Years	Duodenitis	62	52	8	0
3.....	33	M.	17 Years	Gastrojejunal ulcer healed. Duodenal	50	38	16	0
4.....	47	M.	15 Years	Perforating duodenal	70	64	54	40
5.....	32	M.	10 Years	Multiple duodenal with duodenitis	96	80	40	36
6.....	59	M.	30 Years	Chronic bleeding duodenal	40	20	32	20
7.....	35	M.	14 Years	Multiple subacute duodenal	34	24	56	44
8.....	27	M.	5 Years	Multiple chronic duodenal with duodenitis	88	78	28	20

of either the Pólya or the Billroth I type for gastric ulcer, reduction of gastric acidity to a degree of relative achlorhydria occurs in practically every case (Tables V and VI), whereas similar surgical procedures, in which equally large amounts of stomach are removed for treatment of duodenal ulcer, are

TABLE V

RELATIVE ACHLORHYDRIA FOLLOWING PARTIAL GASTRECTOMY OF BILLROTH I TYPE

Case	Age	Sex	Duration of Symptoms	Character of Ulcer	Acidity			
					Preoperative Total	Free HCl	Postoperative Total	Free HCl
1.....	53	M.	7 Months	Gastric	56	44	6	0
2.....	55	M.	9 Months	Chronic hemorrhagic perforating gastric	70	58	10	0
3.....	57	M.	4 Months	Ulcerating gastric lesion	64	52	8	0
4.....	49	M.	3 Months	Chronic gastric	52	40	60	0
5.....	57	M.	6 Weeks	Subacute perforating gastric and duodenal	54	30	8	0
6.....	58	M.	4 Years	Chronic gastric	28	16	36	22
7.....	50	M.	30 Years	Subacute perforating gastric	6	0	12	0
8.....	55	F.	15 Years	Perforating gastric	52	40	10	6

followed in only approximately 50 per cent of cases by relative achlorhydria.¹¹ Interesting in this connection is the fact that after excision of a gastric ulcer and gastro-enterostomy relative achlorhydria will develop in a much higher

percentage of cases than when gastro-enterostomy has been performed for duodenal ulcer. This probably accounts for the fact that gastrojejunal ulcer very seldom occurs following operative procedures for gastric ulcer, providing increased rapidity of emptying of the stomach and dilution of gastric secretion by jejunal secretion are obtained.

TABLE VI

RELATIVE ACHLORHYDRIA FOLLOWING PARTIAL GASTRECTOMY OF POSTERIOR PÓLYA*
TYPE FOR GASTRIC ULCER

Case	Age	Sex	Duration of Symptoms	Character of Ulcer	Acidity			
					Preoperative Total	Free HCl	Postoperative Total	Free HCl
1.....	47	M.	2½ Years	Subacute perforating gastric	76	60	4	0
2.....	58	M.	4 Years	Multiple gastric	48	30	20	0
3.....	44	M.	8 Years	Recurring subacute duodenal and gastric?	46	34	0	0
4.....	58	M.	Several Months	Subacute perforating gastric	60	42	10	0
5.....	56	M.	1½ Months	Subacute gastric perforating ulcerating			8	0
6.....	57	M.	25 Years	Obstructing gastric	40	30	5	0
7.....	40	F.	31 Years	Chronic gastric; chronic duodenal	38	24	4	0
8.....	58	M.	3 to 4 Years	Chronic perforating gastric	60	52	5	0

* Hoffmeister-Pólya type in Case 5.

Studies of preoperative and postoperative gastric acidity, it seems to me, have an important bearing on surgical treatment, both of gastric and of duodenal ulcer, but more particularly of the latter. Since gastrojejunal ulcer does not develop, except in rare cases, in the presence of achlorhydria, those methods which produce anacidity would appear to be superior to others, providing the risk of the procedure was not too great. Unfortunately, the risk of gastric resection, combined with resection of enough of the duodenum to remove the duodenal ulcer, is several times greater than that of gastro-enterostomy or pyloroplasty.¹⁴ This is largely attributable to the difficulty and risk of removal of large or multiple extensive duodenal ulcers as a part of the operation of partial gastrectomy. Other things being equal, the risk in such cases is directly proportional to the size and extent of the ulcer and to the difficulty of closure of the end of the duodenum after removal of part of it. If, therefore, partial gastrectomy for duodenal ulcer can be counted upon to produce relative achlorhydria in only 50 per cent of cases, at a risk considerably greater than that of gastro-enterostomy, and if gastro-enterostomy will reduce gastric acidity to a varying degree in all cases, even to the point of relative achlorhydria in some cases, it would appear that the

additional risk of partial gastrectomy as a routine procedure in the treatment of duodenal ulcer requires justification on some basis other than that of the production of relative anacidity. Such a statement, however, must not be construed as detracting from the advantage of partial gastrectomy in selected cases of duodenal ulcer, particularly those in which the ulcer is of hemorrhagic type, nor in that group of cases in which there is evidence of greater susceptibility to recurring ulceration, nor in treatment of recurring duodenal or gastrojejunal ulcer, for, in cases of recurring ulceration partial gastrectomy practically always will be followed by relative achlorhydria and recurrence of ulceration is exceedingly unlikely. It might appear that in cases of duodenal ulcer in which the preoperative gastric acidity is high, reduction of acidity might not be as great as in cases in which preoperative gastric acidity was lower and that patients whose preoperative gastric acidity was high would be prone to recurring ulceration after gastro-enterostomy. Nevertheless, in innumerable cases in which preoperative gastric acidity was high and the risk of removal of a large, penetrating and infiltrating duodenal ulcer did not seem warranted, I have performed gastro-enterostomy, with the consequence that maximal reduction of gastric acidity occurred (Cases 3, 4 and 5, Table II), even to the point of relative achlorhydria in some cases; moreover, the operations were followed by excellent clinical results.

COMMENT AND SUMMARY

Since reduction in gastric acidity occurs following any operative procedure which, as a result of anastomosis between the stomach and the duodenum or jejunum, allows reflux of intestinal secretion into the stomach, it appears that reduction in gastric acidity is largely attributable to the dilution or neutralization which occurs. Substantiating this conclusion is the fact that relative achlorhydria may occur after gastro-enterostomy as well as in the majority of cases in which resection of the stomach of the Pólya type is performed for duodenal ulcer, whereas loss of this factor of dilution, by performance of entero-anastomosis between the loops of jejunum, is followed by little reduction in gastric acidity.

Following pyloroplasty, or even gastric resection of the Billroth I type, in which the stomach is joined to the duodenum, the percentage of patients who have relative achlorhydria is not so great as when resection of the Pólya type, or gastro-enterostomy, are carried out and anastomosis is made between the jejunum and the stomach. This is probably attributable to the lack of reflux of duodenal secretion into the stomach because following the Billroth I operation, pyloroplasty or gastroduodenostomy the natural peristalsis carries the secretion onward. In contrast, following gastrojejunal anastomosis the peristaltic force carries jejunal secretion into the stomach. It is true that in the Billroth I type of resection and anastomosis as large a portion of stomach usually is not removed as is resected in the Pólya operation; this may or may not be a factor in the proportional reduction of gastric acidity. The response in acidity, to gastric resection for gastric ulcer, whether of the Billroth I or

the Pólya type, is practically universally constant and relative achlorhydria occurs practically without exception. In cases of gastric ulcers in which for various reasons, gastric resection is inadvisable, not infrequently relative achlorhydria will develop after excision of the ulcer when excision is combined with gastro-enterostomy; also interestingly enough, in a few instances when only the gastric ulcer is excised.

Gastric resection is the operation of choice in most cases of accessible, large, callous gastric ulcer and has its place in selected cases of duodenal ulcer, particularly when the ulcer is of the hemorrhagic type, as well as in cases of recurring duodenal ulcer and gastrojejunal ulcer. Furthermore, as time passes, other evidence may present itself, further indicating the value of gastric resection in cases of duodenal ulcer. However, for the present the arguments offered to show that it is better than other procedures are not convincing. These arguments are that in gastric resection the areas of gastritis associated with most ulcers are removed, that relative achlorhydria occurs after gastric resection and that this relative achlorhydria prevents recurring ulceration. However, in my experience gastritis has not been associated with most ulcers; moreover, relative achlorhydria follows gastric resection in only about 50 per cent of cases. And once again, the routine use of an operation which carries an increased risk and which may produce some undesirable physiologic disturbances, seems unwarranted.

A report has come from one clinic concerning 108 cases in which partial or subtotal gastrectomy had been performed for duodenal ulcer. In 47 of these cases relative achlorhydria failed to develop and in nine of the 47 gastrojejunal ulcer developed. This would indicate that among certain groups of patients in certain areas of the United States primary gastric resection for duodenal ulcer may be followed by a greater incidence of recurring ulceration than that which follows the conservative operative procedures of gastro-enterostomy and pyloroplasty or gastroduodenostomy when applied to other groups of patients in other parts of the country.

Lastly, in the evaluation of any operation "the factor of geometrical variation of types of lesions and the part played by racial factors in these differences is as yet unknown to science."¹

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A TECHNIC FOR THE MANAGEMENT OF GASTROJEJUNAL ULCERS WITH OR WITHOUT GASTROCOLIC OR JEJUNOCOLIC FISTULA

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THE technic suggested in this paper has been employed in only five instances. The report therefore is not made on evidence of its proved value, but rather on the theoretical conceptions of its original planning supported by such success as these few cases show.

The thesis is based on certain observations made years ago for a totally different purpose; some of the work of Mann and others on the experimental production and healing of chronic duodenal ulcers; and a determination never again to attempt an operative procedure of the severity carried out in the first patient of this series.

Jejunal ulcers are reported in widely differing percentages by different writers, but from whatever source one draws, they do occur, though perhaps not as frequently as they did when gastro-enterostomy was performed with less discrimination than is now generally practiced.

Jejunal ulcers vary in extent from a small marginal ulcer which offers little or no difficulty to the undoing of a previous gastro-enterostomy, to those extensive ulcers which have destroyed the jejunal wall, penetrated into the thickened mesocolon and are so firmly attached to the under surface of the colon that they cannot be separated from it. The ulcer may have actually formed a gastrocolic fistula. It is for these severer grades of extension that the procedure is designed.

Resection of the jejunum, transverse colon and stomach has been successfully performed in a few instances, but must always be a formidable undertaking, involving a grave risk to life, only to be accepted if no simpler measure can be employed. There have been not a few attempts made to offer means of avoiding such an extensive resection. This is another presented for comment and criticism. I cannot state that I have gone over with certainty all the descriptions of operations designed for the same purpose; but I can say that I have read all the references easily available and have found only one reference which suggested a somewhat similar procedure, reported by Andrews; even here, however, an essential part of the method suggested was not mentioned, namely, the deliberate use of the denuded cuffs to close the stoma without in any way encroaching upon its lumen.

The fate of the first patient in this series emphasized to the writer the necessity for some simpler operative measure than was there adopted. The patient was a man 49 years old, who, five years before, had had a gastro-enterostomy performed upon him for a chronic duodenal ulcer. There was

at the time of gastro-enterostomy a marked delay in emptying the stomach. The gastro-enterostomy had relieved his symptoms for four years, after which he began to experience pain in the epigastrium, loss of appetite, occasional vomiting. The pain was intolerable. The roentgenologic diagnosis was jejunal ulcer.

At operation there was found a mass at the stoma formed by a large ulcer which had destroyed the jejunum opposite the opening. The mass was so firmly fixed to the transverse colon that it could not be separated. An attempt to separate the two resulted in a small opening into the transverse colon.

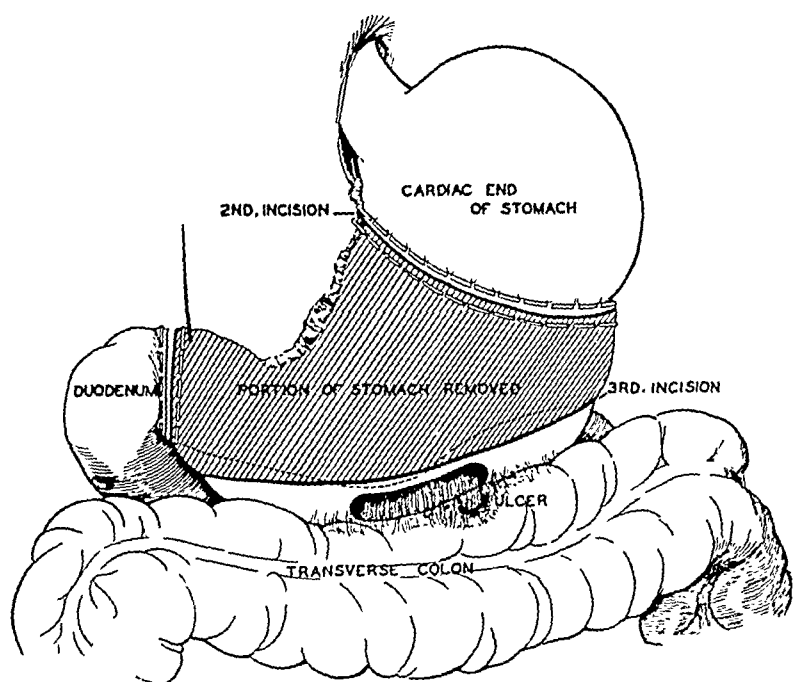


FIG. 1.—Showing the portion of the stomach which will be ultimately removed and the stoma unfortunately not where one could be placed. Its shaded portion is the part of the stomach to be removed. The unshaded portion of the stomach represents the cuff to be left attached to the jejunum above the transverse colon.

It was felt at the time that there was no alternative but resection and anastomosis of the jejunum, transverse colon and stomach. This was effected, and it seemed successful for seven days, when a jejunal fistula developed and he died 14 days after operation.

Years ago, when working with cats on another problem which required the opening and closing of the duodenum, it was found, following a suggestion by Doctor Archibald, that it was possible to get a satisfactory union by scraping away the mucosa from the edges of the bowel incision and then suturing the everted edges instead of the usual inturning as employed in the suture of intestine in the usual anastomosis in the human.

At a later period the same principle was used in resection of the stomach, when for any reason it was desired to cut the stomach cross proximal to the pylorus. Under the circumstances, it makes a clumsy and perhaps unsafe closure to turn the stomach in, as is usually done. The remnant of the

pyloric end of the stomach instead of being inverted was opened, the mucosa dissected off the muscularis down to the junction with the duodenal mucosa. The muscular walls were then sutured together, everting the edges and using no serosal suture. This makes a perfectly satisfactory closure in a section of the stomach just proximal to the pyloric opening.

Experiments by Mann and others have shown that chronic ulcers can be produced by exposing the duodenal mucosa to the gastric secretions unmodified by the normal duodenal contents; further, that these experimental ulcers ordinarily heal if the relationships are restored; if, in other words, the duodenal mucosa is once again protected by its normal alkaline secretion. It has been the experience of surgeons that duodenal ulcers, which cannot be excised, commonly heal when shut off from the gastric juices by one of the operations involving pyloric exclusion.

It was thought that if the jejunal ulcer could be shut away from the gastric contents it would also heal. If at the same time the exclusion of the

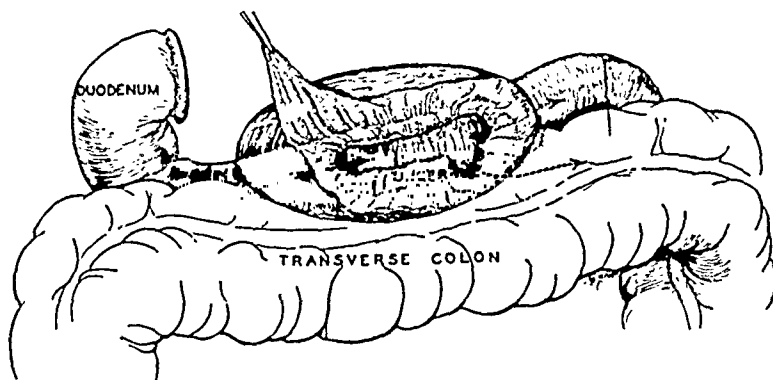


FIG. 2.—Represents the dissection of the gastric mucosa down to the edge of the ulcer. This dissection is easily made because of the looseness of the mucosa of the stomach on the muscularis.

jejunal ulcer could be accomplished without encroaching on the ulcer itself, there would be no need to resect the jejunum and the transverse colon where the ulcer had extended into its wall.

The two requirements, namely, the exclusion of the jejunal ulcer from the acid secretions of the stomach and the closure of the stoma without encroaching on the jejunum, it was thought, could be met by making a wide cuff from the stomach proximal to the stoma. The stomach mucosa could then be carefully dissected away from the inner surface of the cuff, down to the muscularis and right up to the edge of the ulcer. These two broad surfaces could then be sutured together, muscularis to muscularis. In this way the stoma would be closed, the jejunal ulcer and transverse colon left untouched and the ulcer protected from the acid gastric juices. It should heal as does the experimental ulcer and the excluded duodenal ulcer. The stomach could then be resected and the operation concluded by an anterior gastrojejunal anastomosis with or without an entero-anastomosis (Figs. 1, 2 and 3).

Not long afterwards, a patient presented himself with a condition closely resembling that first cited, namely, a definite history of duodenal ulcer for which a gastro-enterostomy had been performed three years before. He was suffering pain, occasionally vomited, the stool showed blood in small quantities; he was losing weight. Roentgenologic examination confirmed the diagnosis of jejunal ulcer. It was decided to operate and apply the theoretically evolved procedure.

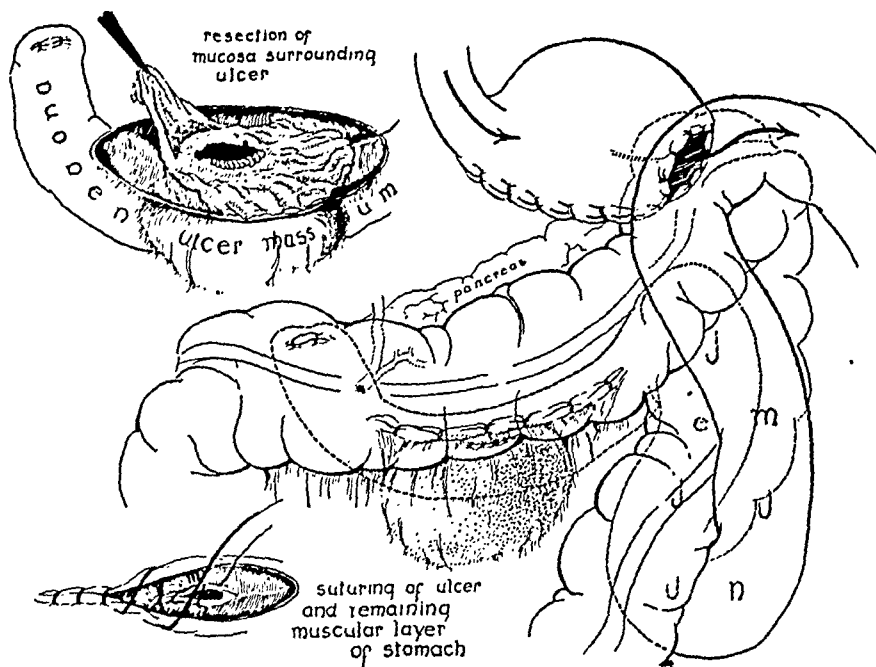


FIG. 3.—Is a composite diagram representing various stages of the closure and the suture of the surfaces of the denuded stomach cuff.

CASE REPORTS

Case 1.—Mr. P. 84711. Age 49. Chief Complaint.—Pain in epigastrium, blood in the stools. History.—There has been a vague abdominal history for ten years. One year ago he was operated upon for a duodenal ulcer, and a posterior no loop gastro-enterostomy was performed. Three months ago pain recurred and roentgenologic examination revealed a jejunal ulcer as indicated by a "rest" after the barium meal.

Operation.—April 12, 1933. A large mass of inflammatory tissue was found in the neighborhood of the gastro-enterostomy opening. It was two and one-half inches long and two inches in diameter, and situated immediately under the transverse colon. The transverse colon itself was edematous and thickened. The stomach was dissected free; cut across as if for a three-quarters resection. In this way it was entirely freed, except for its attachment to the jejunum. A cuff of stomach was then cut one and one-half inches from the edge of the stoma. The mucosa was carefully dissected off the muscularis down to the edge of the ulcer until all the stomach mucosa was removed.

It could then be seen that there was a large ulcer in the jejunum at least one and one-half inches in diameter, of which one wall must have been formed by the transverse colon. The stoma was closed by suturing together the inner surfaces of the stomach cuff, and the operation completed by an anterior gastrojejunostomy, to the remnant of the stomach.

The patient was immediately relieved of his pain and during the subsequent three months gained 30 pounds. He was well until the autumn of 1935, when he returned, complaining of pain. Roentgenograms suggest that he has a second jejunal ulcer at the site of the new opening.

Case 2.—Mrs. E. 88251. Age 60. Admitted February, 1934. Chief complaint.—Eruclations of gas with a foul odor, loss of weight and strength. She had had a gastro-enterostomy in 1921, but was never free from symptoms. In July, 1933, she noticed pain and had eruclations of foul smelling gas followed by diarrhea. A diagnosis of jejunal ulcer with gastrocolic fistula was confirmed by roentgenologic examination.

Operation.—February 24, 1934. The transverse colon was firmly attached to the jejunal opening and gas could be expelled from the colon into the stomach. The first step consisted in freeing the stomach from adhesions and tying the vessels along the greater and the lesser curvature. The duodenum was cut across and turned in, the stomach also as for a three-quarter resection. In this way it was freed except for an attachment to the jejunum. A cuff was then fashioned from the stomach; the mucosa dissected off to the edge of the ulcer and the stoma closed by suture of the two surfaces together, muscularis to muscularis. An anterior gastrojejunostomy completed the repair, leaving the ulcer and fistula intact.

Immediately following the operation she was relieved of pain and the eruclations of foul gas ceased. She took nourishment and seemed on the way to recovery for four weeks, when she suddenly collapsed and died from peritonitis due to a leak from the corner of the anterior anastomosis.

At the autopsy the ulcer was shown not to be healed; the fistula had closed and the ulcer was definitely smaller than at operation.

Case 3.—J. P. Age 48. Admitted May, 1933. Chief Complaint.—Pain in the epigastrium not related to, or relieved by, food. Bleeding from the bowel. Operation five years before gastro-enterostomy for duodenal ulcer with obstruction. Recurrence of symptoms during last three months. Roentgenologic diagnosis of jejunal ulcer.

Operation.—May, 1933. Dense adhesions were found to the anterior abdominal wall. A large mass was present representing an ulcer of the jejunum opposite the stoma and firmly adherent to the transverse colon. The stomach was freed, and resected. A cuff was then fashioned from the stomach, the mucosa dissected off and the stoma closed by suturing the opposed surfaces of the stomach wall one to the other. The operation was completed by an anterior gastrojejunostomy.

The patient was relieved of his pain, bleeding stopped and he has been fairly well since. He had occasional distress for three to four months, after which he could eat fairly freely without pain.

Case 4.—M. J. Age 37. Admitted May 3, 1933. Chief complaint.—Pain in abdomen, vomiting and tenderness in epigastrium. He had been operated upon in 1923 and a gastrojejunostomy performed. He was fairly well for nine years, but was readmitted in 1932 for pain. Roentgenologic diagnosis of jejunal ulcer.

Operation.—June 16, 1933. Many adhesions were found attaching the stomach to the anterior wall. The transverse colon was firmly attached to the stomach near the stoma as was the jejunum to the colon. There was a small mass felt in the region of the stoma.

The stomach was gradually freed from adhesions till the pylorus and duodenum were prepared for resection. The stomach was cut across one inch proximal to the pylorus, and the pylorus closed by dissecting off the gastric mucosa and suturing the muscle surfaces together. The stomach was then cut across as for a resection. The main portion of the stomach was then cut away from the stoma, leaving a fringe or cuff of stomach wall about one and one-half inches wide. The gastric mucosa was dissected off down to the stoma and the stoma closed by suturing the bared surfaces together; and the repair completed by an anterior gastro-enterostomy.

This patient might have been dealt with by other methods, but this seemed to the writer to be easy and has had a good result. He has gained 15 to 16 pounds; no pain, no vomiting, no acidity. He is working and taking ordinary food, other than fried or spiced.

Case 5.—H. B. Age 52. Admitted September, 1932. Chief complaint.—Pain in the abdomen, loss of weight, tenderness and pallor. He had been operated upon for gastric

ulcer in 1927. Symptoms recurred in 1932. Roentgenologic diagnosis, doubtful jejunal ulcer.

Operation.—September 20, 1932. A hard mass was found in the region of the gastro-enterostomy opening. After dissection this was found to be an ulcer more on the stomach than the jejunal side of the anastomosis. As in other cases, the stomach was dissected free, the stoma closed by making a cuff from the stomach wall and closure effected by suturing these surfaces together after dissecting off the mucosa. The final anastomosis was made posteriorly, because the mesentery of the small intestine was too short.

This patient was discharged in 28 days, feeling well, but still on a restricted diet; he had no pain or vomiting and was gaining weight.

The principles here made use of seem so evident that they must often have been used; but I have read with some degree of care several of the larger bibliographies and have not, as it seemed to me, found them so clearly enunciated as to form the basis of a planned method of treatment. If this is an old story, then these cases are offered as additional evidence of its usefulness. If there is anything new, it may be found worthy of your consideration.

DISCUSSION.—DR. WILLIAM L. ESTES, JR. (Bethlehem, Pa.).—I have been very much interested in Doctor Scrimger's technic, because four years ago we reported a somewhat similar procedure before the Johns Hopkins Surgical Society. It was a patient upon whom a posterior gastro-enterostomy had been performed in conjunction with the closure of a perforated ulcer, seven years before. He had also had a perforated jejunal ulcer two years before he came to us for treatment. Examination disclosed evidences of marked obstruction in and about the gastrojejunal area, resulting from a large ulcer. He also had been having repeated hematemeses and evidences of gastric retention.

At operation we found a hugely dilated stomach above a very extensive gastrojejunal ulcer, the type Doctor Scrimger has described, with its base very close to the transverse colon—intimating that there might shortly have developed a gastrocolic or jejunocolic fistula. There were present a dilated proximal jejunum and a rather marked obstruction in what was the distal loop of the previous gastro-enterostomy, the site of the former perforated jejunal ulcer.

Primarily, we had a very bad risk patient to deal with. Therefore, our first procedure, similar to the first stage of Doctor Scrimger's operation, was to expose the gastrojejunal ulcer from above through an opening in the gastrocolic omentum. The stomach was easily separated from the upper margin of the stoma. The opening into it was closed by a double layer of sutures. The upper margin of the stoma, without disturbing the mucosa, was turned in and firmly closed by two layers of sutures. The operation was concluded by making an anastomosis between the distal and proximal loops of jejunum, thus side-tracking the ulcer.

The remarkable thing was not the fact that he did quite well after the operation, but that he returned after nine weeks with evidences of reactivation of his old duodenal ulcer. At reoperation we found that there had been complete healing of the gastrojejunal ulcer area. There was no further induration in the mesentery of the transverse colon, and there was a marked atrophy of the side-tracked loop of the jejunum.

I therefore believe that this, or an operation similar to the one Doctor

Scringer reported, has a place in the treatment of these very advanced cases of gastrojejunal ulcer.

DR. FRANK H. LAHEY (Boston, Mass.).—May we ask Doctor Scringer how he avoids regurgitant fecal contamination. I presume he must have some plan.

DR. FRANCIS A. C. SCRINGER (Montreal, Canada) closing.—I have nothing to add except to indicate that my suspicions were correct, and that the ideas contained in this had been already recognized, although my diligence had not been sufficient to discover them all, and to point out that it seemed to me an advantage that the removal of the gastric mucosa was perhaps a principle worthy of some consideration.

Relative to Doctor Lahey's query concerning contamination, I have no plan for that, because in only one case was the fistula present, and it was quite small, and while there had been regurgitant contamination into the stomach, at the time the bowel did not regurgitate.

EXPERIMENTAL LYMPHEDEMA OF THE INTESTINAL TRACT AND ITS RELATION TO REGIONAL CICATRIZING ENTERITIS*

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THE anatomic, physiologic and embryologic studies of the lymphatics during the past 300 years have firmly established them as a definite part of the vascular system. The clinical importance of this system of vessels and nodes has only recently been realized as new methods have been developed for the study of its physiologic functions and pathologic alterations.

Investigators learned, as had been ascertained previously for the blood vascular system, that the lymphatics grew into new tissues, that they regenerated and developed a collateral circulation, that they became inflamed, sclerosed and thrombosed. Recently it was found that lymphatics could be obliterated in an extremity resulting in a chronic lymphedema or elephantiasis. This same method may be applied to the lymphatics of other parts of the body and to various organs. We became interested in the effect of obliteration of the intestinal lymphatics in localized portions of the bowel after observing somewhat unusual lesions in clinical cases in which the appearance of the bowel, after the possibility of malignancy was eliminated, suggested a chronic lymphatic obstruction.

Resected bowel from three such cases, seen on the surgical service, was classified as cicatrizing regional enteritis and its pathologic study revealed a marked edema and fibrosis of the wall and engorgement of the lymphatics. We felt this picture resembled in many details that of chronic lymphedema or elephantiasis, as seen in the extremities. The two dominant features of the intestinal lesion seemed to be a low grade chronic infection with a concomitant chronic lymphatic obstruction and edema.

Fortunately for us the work of Drinker, Fields and Homans¹ on the experimental production of lymphedema and elephantiasis in the limb of dogs had been just published. Some years ago one of us,² at the suggestion of the late Professor Halsted, had attempted to produce elephantiasis in animals but the work reported by Homans, Drinker and Fields³ presented a satisfactory experimental method of obtaining chronic lymphedema which we have applied in the study of this condition in the intestinal tract of dogs.

METHOD.—Drinker and Fields developed an elaborate method of tying a fine quartz cannula into the lymphatic vessel through which a 2½ per cent solution of quinine hydrochloride combined with a suspension of crystalline silica dust was slowly injected. By repeated injections of the irritating and

* Aided by a grant from the Fluid Research Fund of the Rockefeller Foundation.

sclerosing materials the lymphatic vessels and nodes were injured and became obliterated by a fibrosis, producing the condition of chronic lymphedema.

During previous experimental work on the lymphatics,⁴ under Doctor Sabin, a technic for lymphatic injection was developed, using fine hypodermic needles, gauge 27 and 28, attached to a tuberculin syringe. We found this method well adapted for the direct injection of the mesenteric lymphatics as well as of the subserosal lymphatics of the bowel, without interfering in any way with the intestinal blood vascular network, thereby allowing the study of the isolated effect of lymphatic occlusion in the intestinal tract and the end-results of lymphatic fibrosis produced by irritating and sclerosing materials. Adjacent bowel with undisturbed lymphatic drainage to uninvolved lymph nodes was used as a control in these studies.

The material used for lymphatic injections included crystalline silica (200) mesh, Hill's bismuth oxychloride mass, as modified by Poth⁵ for lymphatic injection, rose aniline dye in the form of indelible lead, or sodium morrhuate added to the bismuth mass as a sclerosing material. In some instances appendiceal contents were added to the bismuth mixtures before injection and in others a suspension from 24 hour broth culture of *B. coli* was given intravenously one to three hours before the lymphatic injections. One, two or three reinjections were made in a number of animals at intervals from several weeks to months after the preceding treatment.

Subserosal lymphatic injections in the stomach and pylorus were difficult to effect, but subserosal and mesenteric lymphatics could be injected readily in the duodenum, distal ileum and proximal large bowel. The mesenteric lymphatic vessels of the ileum were filled easily and, at times, these were the only injections made at the first operation, with mesenteric and subserosal injections made at subsequent explorations (Fig. 1). The present report will be confined to the results of lymphatic obstruction in the ileum and colon.

A paralysis or dilatation of the intestinal lymphatics was noted when intravenous bacteria had been given an hour before operation, and the lymphatic dilatation was particularly remarkable in three animals made sensitive to foreign protein by seven intravenous injections of horse serum during the previous six weeks. In these animals a final injection of serum was given just before operation. Evidence of anaphylactic shock was apparent by the cold skin and the cold intestines, which were pale, relaxed and showed no peristalsis on irritation. The arteries and veins were contracted, but the lymphatics and lacteals were found to be dilated or paralyzed, were easily injected and appeared as large vessels in the mesentery, subserosa and between the muscle layers.

The experiments were concluded by sacrificing the animals under ether anesthesia. The most satisfactory procedure for fixation was to remove the whole gastro-intestinal tract, to separate any adhesions or matted loops of bowel under warm saline and then to fill partially the lumen with warm saline. When all of the intestines were completely relaxed they were quickly put into formalin, thus insuring simultaneous contraction and fixation of all

parts of the tract. Areas of the treated and normal bowel were excised later for microscopic study.

EXPERIMENTAL RESULTS.—No free peritoneal fluid was ever seen upon opening the abdomen for subsequent reinjection, or when the animal was sacrificed, but adhesions about the injected mesentery and between the omentum and loops of treated bowel were encountered frequently. The treated



FIG. 1.—Roentgenogram of normal ileum and mesentery in which the lymphatics were injected directly with bismuth oxychloride (26 per cent) in an acute experiment. (a) Tip of appendix. (l.) Ileum. (L.G.) Regional lymph node filled partially with bismuth from mesenteric lymphatic and subserosal lymphatic injections. (L.) Lacteal filled from subserosal injection.

segment felt thickened, and some of the mesenteric lymphatics were dilated while others were sclerosed. The regional lymph nodes were enlarged and firm, and the involved mesentery frequently scarred. In only one animal did the injections fail to produce chronic pathologic changes persisting for months to a year.

Specimens were studied from 19 dogs in which there were intestinal lymphatic injections. Bismuth oxychloride (26 per cent) alone was used in three injections, bismuth oxychloride and sodium morrhuate (5 per cent), equal parts, were used in 15 injections, while the mixture of bismuth and rose aniline dye was employed seven times. Silica and rose aniline dye were used only twice because the silica interfered with the smooth movement of the plunger of the syringe. Bacteria mixed with the bismuth and rose aniline

dye were used twice, and intravenous injections of *B. coli*, followed in one to three hours by lymphatic injections with bismuth and the dye or sodium morrhuate, were used four times.

ACUTE LYMPHEDEMA.—Six animals died or were sacrificed at intervals



FIG. 2.—L 1. Four and one-half week specimen. (a) Normal ileum (X34). (b) Ileum (X34), mesenteric lymphatics injected with bismuth oxychloride, showing muscle layers edematous and thickened four to five times more than normal. Lacteals engorged. Submucosa thickened and infiltrated.

from a few days to two weeks. The histologic picture varied with the length of survival. The thickened bowel wall showed inflammation and thickening of the serosa and edema of the circular and longitudinal muscles, with the lacteals in the intermuscular septum distended with fluid and lymphocytes.



FIG. 3.—L 14. Nine and one-half week specimen. (a) Normal ileum (X20). (b) Ileum (X20). Intravenous injection of *B. coli*, followed in three hours by mesenteric and subserosal ileac lymphatic injections of bismuth and rose aniline dye. Inner circular and outer longitudinal muscles edematous and eight times normal thickness. Lacteals engorged and thrombosed. Submucosa greatly infiltrated, 15 times normal thickness.

The submucosa was swollen and infiltrated with leukocytes and its lymphatics were engorged with cells. The mucosa seemed a little swollen but there were no ulcerations.

Between two and four weeks after injection the lymphatics were noticeably

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filled with very large pale cells containing large pale nuclei, and the vessels seemed thrombosed and sclerosed, so that a chronic stage had developed.
CHRONIC LYMPHEDEMA.—In 13 animals the lymphatic injections had been

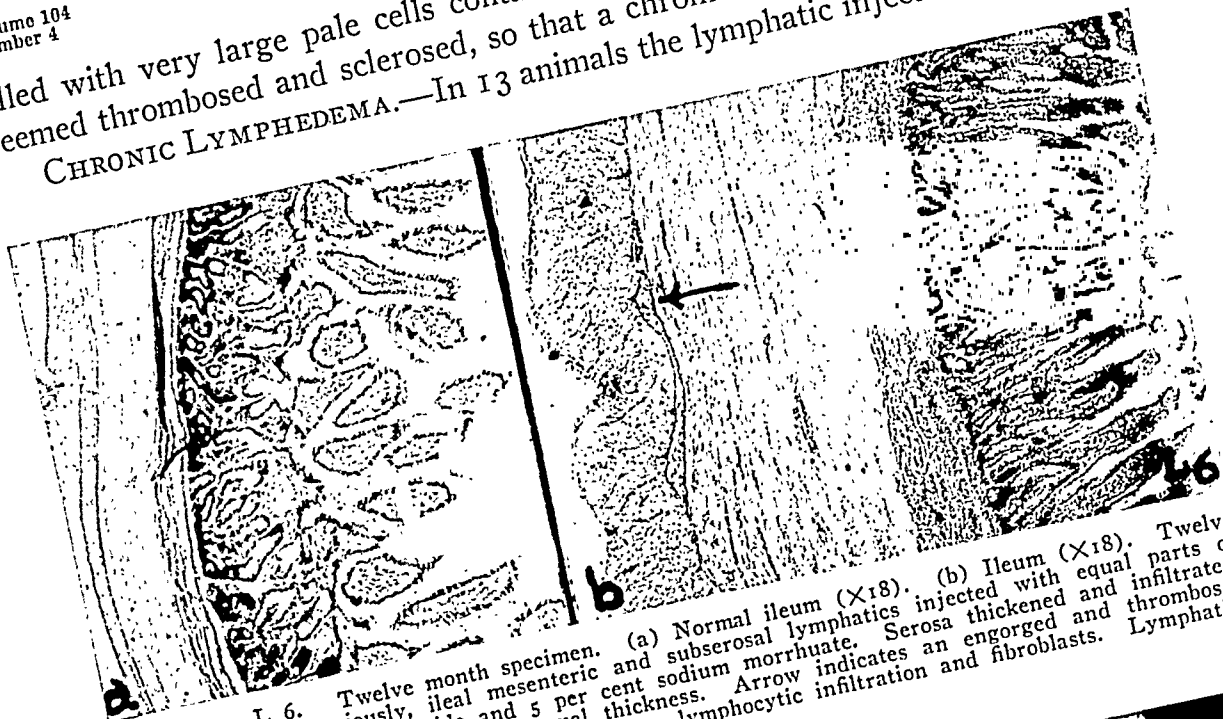


FIG. 4.—L 6. Twelve month specimen. (a) Normal ileum (X18). (b) Ileum (X18). Twelve and ten months previously, ileal mesenteric and subserosal lymphatics injected with equal parts of 26 per cent bismuth oxychloride and 5 per cent sodium morrhuate. Serosa thickened and infiltrated. Muscles edematous and four times normal thickness. Arrow indicates an engorged and thrombosed lacteal (Fig. 5). Submucosa thickened by edema, lymphocytic infiltration and fibroblasts. Lymphatics engorged and thrombosed.



FIG. 5.—L 6. High power (X650), of intermuscular thrombosed lacteal (c), engorged with large pale mononuclear cells. The adjacent outer longitudinal (a) and inner circular (b) muscles are pale and edematous.

made one month or longer before death and all except one showed definite gross and microscopic alterations in the involved bowel. Of the 12 dogs that had developed a chronic lymphedema three were injected only once, six

were injected twice, two were injected three times and one was injected four times. Yet all had the same characteristic histologic changes.

That chronic pathologic changes which persisted, without subsidence, for months should develop after even a single injection of irritating and sclerosing substances into the intestinal lymphatics was striking and unexpected.

The main differences between the acute and the chronic changes following the injections were found to be in the lymphatics and in the submucosal and muscular layers. With subsidence of the acute phase the signs of inflammation disappeared, and only round cells and lymphocytes were to be seen. The edema of the tissues persisted, since the submucosal lymphatics and the lacteals lying between the muscular layers had been obliterated by sclerosis or thrombosis, and were now filled with firm trabeculations and packed with very large, pale cells containing large, lightly staining nuclei (Fig. 5). The greatest change was a thickening of the longitudinal and circular muscles and

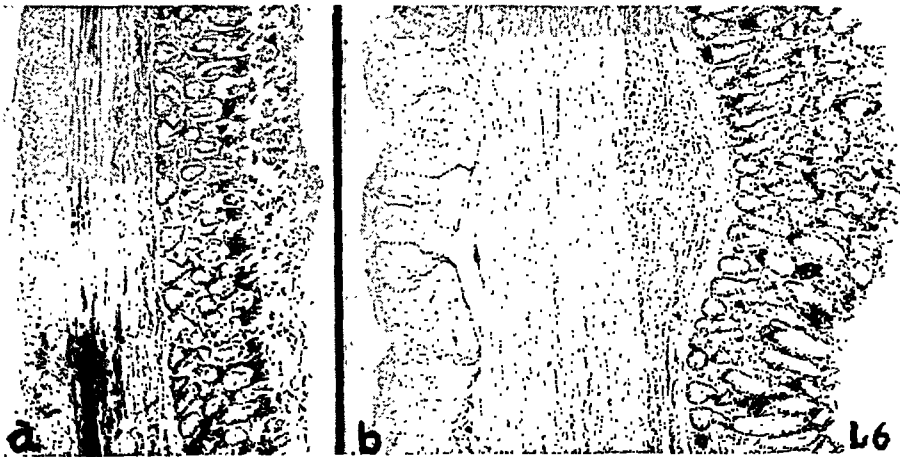


FIG. 6.—L 6. Twelve month specimen. (a) Normal colon (X24). (b) Colon (X24). Twelve and ten months previously subserosal lymphatics injected with equal parts of 26 per cent bismuth oxychloride and 5 per cent sodium morrhuate. Serosa thickened and fibrinous. Muscles edematous and two to three times normal thickness, with lacteals engorged and thrombosed. Submucosa thickened, infiltrated and fibrosed.

in the submucosa, these being two to eight times thicker than normal; and due to the chronic edema present the muscle fibers were found to be swollen and indistinct (Figs. 2, 3, 4, 5 and 6). Edema, fibrin and fibrosis persisted in the submucosa, and usually the serosa was somewhat thickened (Figs. 4 and 6). No ulcerations of the mucosa were seen.

These pathologic changes were seen in all the 12 specimens, and no appreciable differences were found following injections of bismuth in conjunction with sodium morrhuate (Figs. 4, 5 and 6) or rose aniline dye, and of silica in conjunction with the aniline dye. Bismuth alone (Fig. 2) produced definite alterations, but the most marked chronic lymphedema occurred when *B. coli* was given intravenously shortly before the lymphatic injections of bismuth and rose aniline dye (Fig. 3).

The end-result of sclerosing and obliterating the lymphatics to a segment of intestine was to produce a bowel thickened from chronic lymph stasis with the lymphedema most marked in the submucosal and muscular layers. This

characteristic pathologic picture (Figs. 2, 3, 4 and 6) was found in 12 specimens, although the number of injections ranged from one to four, although several different sclerosing materials had been used and although one to ten months had elapsed between the injections and the autopsy.

PROTOCOLS

Since the number and location of the lymphatic injections, the substances used for lymphatic sclerosis, and the gross pathologic observations at reoperation or autopsy have been summarized, it will not be necessary to give the details in all of the experiments. The reports of three experiments, with photomicrographs, are presented briefly to illustrate the findings in chronic lymphedema of the ileum and colon.

L-1.—On October 24, 1934, the mesenteric lymphatics were directly injected close to the ileum with 26 per cent bismuth oxychloride. The white bismuth filled these lymphatics and finally filled the regional lymph node, draining about 12 to 15 inches of the terminal ileum. No subserosal lymphatic injection was made.

November 11, 1934. Three weeks later an exploration was made. The ileum was bound down by adhesions, and the injected lymph node was quite large. One distended ileac mesenteric lymphatic was reinjected.

On November 26, 1934, four and one-half weeks after the first injection, the dog was sacrificed. No free fluid or distended loops of bowel were seen. A large mass of matted loops of small bowel in the cecal region with shortened and thickened mesentery was dissected free. A large ileal lymph node was surrounded by fibrous adhesions. The intestinal tract was partially distended and fixed in formalin for one hour, then incised longitudinally at the antimesenteric border and wrapped loosely on a plate of glass for further fixation. The terminal six inches of ileum were thickened but no mucosal ulcerations were seen.

Microscopic Findings.—The section from the injected ileum (Fig. 2 b) showed the serosa very thick and infiltrated.

The inner circular and outer longitudinal muscles were four to five times thicker than the normal ileum (Fig. 2 a) and were edematous, with slight round cell infiltration and with the lacteals engorged with so called plasma cells and very large, pale cells. The submucosa was thickened and infiltrated with engorged lymphatics. The mucosa was intact.

L-14.—On August 1, 1935, at 12:30 P.M., three-fourths of a cubic centimeter of a 24 hour broth culture of *B. coli* was given intravenously. At 2:30 P.M., five ileal mesenteric lymphatics were injected with bismuth oxychloride, which was colored a deep purple by adding a piece of indelible lead (rose aniline dye). Four subserosal lymphatics were injected in the ileum, two in the appendix and one in the proximal colon three inches from the ileocecal valve.

On October 7, 1935, nine and one-half weeks after injection, the animal was sacrificed. No free fluid or adhesions were seen. Definite thickening of the terminal ileum was felt. The intestinal tract was removed, partially filled with warm saline and, when entirely relaxed, put into formalin.

Microscopic Findings.—Section of the injected ileum (Fig. 3 b) showed the serosa edematous and slightly infiltrated. The muscles, especially the inner circular, were markedly thickened to eight times that of the normal ileum (Fig. 3 a) and showed edema and slight round cell infiltration with engorged and thrombosed lacteals. The submucosa was greatly infiltrated with dense areas of round cells and engorged lymphatics, and was 15 times thicker than in the control section. The mucosa was intact. The nor-

mal ileum (Fig. 3 a) showed a single layer of serosal cells with the muscle fibers distinct and the lacteals containing only lymph. In the submucosa the lymphatics were small.

L-6.—On December 13, 1934, the distal 12 inches of the ileal mesentery had the lymphatics injected, and four subserosal ileal lymphatics were also injected with equal parts of bismuth oxychloride (26 per cent) and sodium morrhuate (5 per cent). Subserosal lymphatic injections were also made on the proximal three inches of large bowel.

On January 28, 1935, six and one-half weeks later, reinjection of lymphatics was done. Only a few omental adhesions were seen. The ileum was thickened. Many subserosal lymphatics in the distal ten inches of ileum were readily injected and filled the deeper enlarged lacteals. The colon was thickened. Three subserosal lymphatics in the proximal colon were injected.

On November 7, 1935, nearly 12 months after the first, and ten months after the second injection, the animal was sacrificed. After mesenteric adhesions of the ileum were divided, definite thickening of ileum, appendix and proximal colon was felt.

Microscopic Findings.—In the sections of the injected ileum (Fig. 4 b), the serosa was thickened and contained dilated, thrombosed lymphatics. The inner circular muscle was edematous with the muscle fibers swollen and lacking detail (Fig. 5 b). Some wandering cells were seen. The longitudinal muscle showed the same edematous condition (Fig. 5 a). The muscle layers were four times thicker than in the normal ileum. Engorged lacteals (arrow in Fig. 4, and Fig. 5 c) were filled with large pale cells and showed thrombosis and, in some areas, cannulization. In the submucosa some round cell infiltration was seen just beneath the mucosa and there were frequent fibrin deposits and marked fibrosis causing this layer to be twice as thick as in the section of normal ileum (Fig. 4 a). Engorged and thrombosed lymphatics were numerous. The mucosa was intact. The section of the normal ileum (Fig. 4 a) showed the muscle fibers to be sharp and distended. The lacteals were not thrombosed, and they contained an occasional large pale cell. The serosa was composed of a single layer of cells.

In the section of the injected colon (Fig. 6 b) the findings were similar to those in the ileum with the serosa thickened and fibrinous. The muscles were two to three times thicker than normal, and were edematous. The lacteals were engorged and thrombosed. The submucosa was thickened, infiltrated and fibrosed. Five or six layers of lymphocytes were seen beneath the musoca, instead of two or three layers in the normal colon (Fig. 6 a).

REGIONAL CICATRIZING ENTERITIS.—In these experiments the constant pathologic changes, grossly and microscopically, that became chronic and persisted for months after regional sclerosis and obstruction of the intestinal lymphatics to a portion of the ileum or colon, resembled in many respects the pathologic picture in clinical cases of regional cicatrizing enteritis. Many recent reports of cases showing this clinical entity have been published so that the symptoms, signs, and diagnosis of this disease need not be considered in this paper, although a short description of the pathologic findings obtained from the literature and studied in three of our clinical cases will be given.

When Crohn, Ginzburg and Oppenheimer,⁶ in 1932, separated a subgroup from the benign, nonspecific granulomata and described regional enteritis as a pathologic and clinical entity, they stated that the etiology of the process was obscure. They felt that this disease of the terminal ileum was characterized by a subacute or chronic necrotizing and cicatrizing inflammation of all the coats of the ileum, which frequently led to stenosis of the lumen and was often associated later with fistulous formation and a palpable tumor in the right lower quadrant.

ETIOLOGY.—In the Stanford clinic, in September, 1933,⁷ a unique and original observation was made in a case of presumed regional ileitis in a child aged six, all previous observations having been made in adults. In this patient, the lesion was completely excised, including the terminal ileum and four inches of the cecum. The mucosa of the ileum, appendix and colon was everywhere intact but characterized by an extensive diffuse edema which involved also the mesentery and regional lymph nodes. An extensive fibrosis accompanied this edema producing the localized mass. It was inferred from these observations in a child that the process was primarily a lymphadenitis and that ulceration of the mucosa, when present, was secondary to the lymphatic obstruction and infection.

Bell,⁸ in 1934, reported that he was unable, by interference with the blood supply of the intestinal tract in animals, to produce a cicatrizing enteritis, ulceration of the mucosa or any lesion simulating this condition, and concluded that the pathologic process in this disease was not one of inadequate blood supply. Bell raised the question whether the etiologic factor was infection in the mucosa spreading to the intestinal wall with edema of the mesentery from inadequate lymphatic drainage, or whether it was an infection starting in the lymphatics as a lymphangitis, and extending to the wall of the bowel.

Bockus and Lee⁹ stated that any primary inflammatory mucosal disease in the terminal ileum might in the end resemble the entity of regional ileitis. Ginzburg and Oppenheimer,¹⁰ for instance, suggested a disturbance in the vascular mechanism, as found in self-reducing intussusception or recurrent partial volvulus, as a possible rôle in this disease, and Homans and Haas,¹¹ Erb and Farmer,¹² and others suggest primary appendiceal disease as an etiologic agent with secondary involvement of the mesentery and, finally, the terminal ileum. Bockus and Lee⁹ conceive the possibility of a lymphangitis and surrounding inflammation which might encroach upon or infect the blood supply, producing a slow devitalization of the terminal segment of ileum, resulting in terminal ileitis. Felsen¹³ offers evidence that a great majority of cases of chronic, nonspecific, ulcerative colitis and ileitis, and nonspecific granuloma are the chronic stages of acute bacillary dysentery.

Clinical Pathologic Reports.—The description of the clinical entity involving the terminal ileum was made in 1932, but subsequent reports have been made of similar pathologic conditions which involve the jejunum, ileum, cecum and colon, so that the term chronic cicatrizing enteritis, as suggested by Harris, Bell and Brumm,¹⁴ is more comprehensive.

Crohn and his associates studied specimens obtained from patients who had been ill for at least a year. Ulceration of the mucosa with blunting of the villi from edema, marked inflammatory, hyperplastic and exudative changes in the submucosal and muscular layers, and thickened, fibrotic serosa produced an enormously thickened intestinal wall which encroached upon the lumen. The mesentery was greatly thickened and fibrotic. Histologically, various degrees of acute, subacute and chronic inflammation were shown by

the presence of polymorphonuclear, round cell, plasma cell and fibroblastic elements. In some cases the presence of giant cells was striking. Near them were inclusion vegetable cells which had apparently resulted in the formation of the giant cells. After careful study they found no evidence of tuberculosis, syphilis, actinomycosis, Hodgkins' disease or lymphosarcoma.

An important contribution to the clinical study of this disease was the presentation of an early stage as reported by Erb and Farmer,¹² who gave an account of four children with acute ileocolitis simulating appendicitis and characterized by edema of the ileocecal region and mesenteric nodes. They felt that the disease they described was closely related to regional ileitis, or chronic cicatrizing enteritis or benign granuloma of the intestines. The pathologic finding in their fourth case—of a child two and one-half years old, ill for six days—was almost identical with the findings observed in the acute cases described by Crohn¹⁵ where the terminal ileum was found to be thickened, soggy, and edematous, the serosa a blotchy red and the mesentery greatly thickened and containing numerous hyperplastic nodes. Histologically the mucosa was ulcerated and covered with a thick layer of exudate. The lymphoid tissue had undergone marked necrosis. Extensive fibrin formation was seen, and many large mononuclear cells interpreted as endothelial leukocytes were present in the intestinal wall. They noted a sparsity of polymorphonuclear cells. The edema led to a marked increase in thickness of the bowel wall and involved the muscular layers and particularly the submucosa.

CASE REPORTS

Case 1.—It was this specimen of chronic ileitis (Fig. 7) resected by Dr. G. Nagel from a man (E. D.), aged 27, that suggested to us a picture resembling chronic lymphedema and led to the experimental production of chronic intestinal lymphedema herein reported. In the photograph a match stick indicates the sinus from the cecum that had persisted for two years subsequent to an appendectomy.

The greatly thickened terminal ileum when cut showed the serosa thickened by areolar and fibrous tissue which had a heavy perivascular infiltration of round cells (Fig. 8). The muscles were greatly thickened, edematous and the inner circular muscle layer was heavily infiltrated with fibroblast and round cells adjacent to the submucosa, which likewise showed marked fibrosis and infiltration. The thrombosed lacteals were engorged with the large pale cells and the submucosal lymphatics were thrombosed and distended with the same large mononuclear cells. The mucosa was ulcerated in places, and elsewhere it was heavily infiltrated with lymphocytes, and leukocytes. Lymphoid tissue and clusters of lymphocytes were frequently seen beneath the mucosa and the serosa.

Case 2.—In Holman's⁷ discussion of Bell's⁸ paper, he reported the boy, aged six (C. L.), who had symptoms of appendicitis for only one day, but in the preceding two years had had occasional abdominal pain. At operation the expected appendiceal abscess was found to be a firm mass, involving the terminal ileum, cecum and base of the appendix which was resected. The mesentery was short and thick, and had enlarged lymph nodes.

Our pathologic study of the tissue showed the terminal ileum and appendix to be edematous and thickened with the ileal mucosa studded with lymphoid masses and numerous petechial hemorrhages but no ulceration. The submucosa was thickened and showed thrombosed lymphatics and scattered round cell infiltration. The muscle layers

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were greatly thickened and distorted, showed moderate lymphocytic infiltration and their edematous condition was seen by the indistinct outlines of the muscle fibers (Fig. 91). The lacteals were engorged with large pale cells which some writers have described as



FIG. 7.—Case 1. ($\times\frac{1}{2}$.) Specimen of chronic ileitis showing ulcerations of mucosa and greatly thickened and edematous wall. Match stick indicates sinus from cecum persisting after appendectomy.

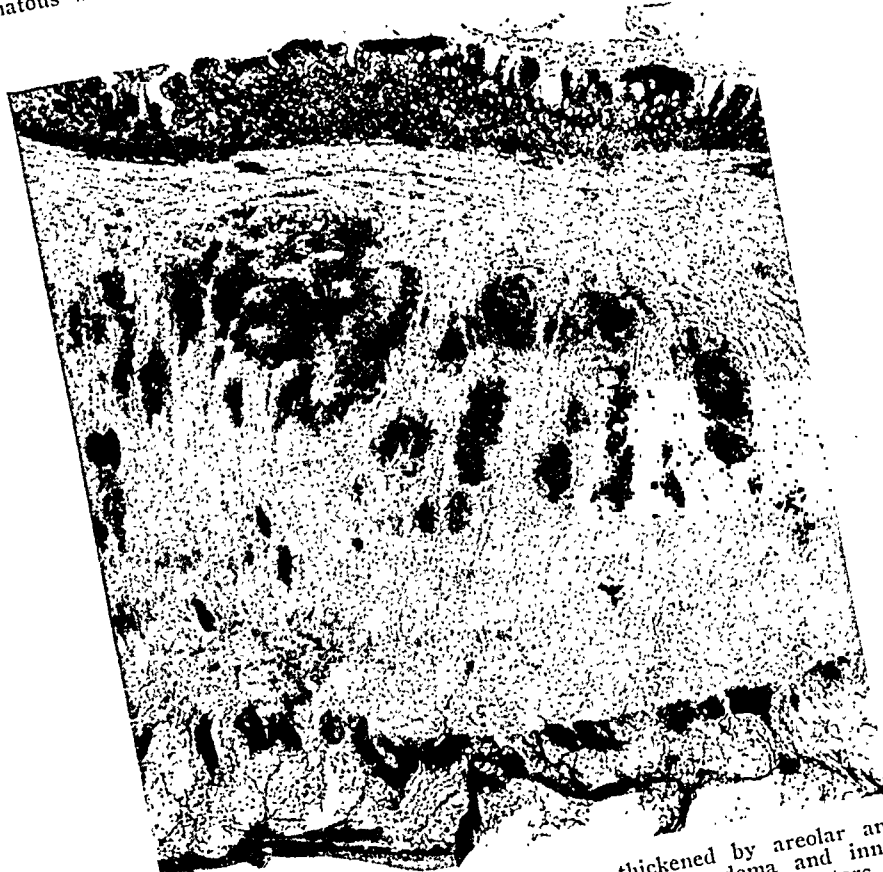


FIG. 8.—Case 1. ($\times 7$.) Serosa thickened by areolar and fibrous tissue. Muscles greatly thickened by edema and inner circular layer heavily infiltrated with fibroblasts and clusters of lymphocytes. Lacteals and submucosal lymphatics thrombosed and engorged with large pale mononuclear cells.

large mononuclear cells without identifying their location in lymphatic vessels. The serosa was thickened, fibrinous, and infiltrated with round cells.

Case 3.—A man (M. P.), aged 40, suffered a severe blow on the abdomen from

the steering wheel of his automobile. Two weeks later occasional severe abdominal cramps developed, frequently associated with vomiting and diarrhea. Two months later the cramps were occurring day and night and, on admission, visible peristaltic waves were seen, and a mass in the left lower quadrant was felt. On operation for intestinal obstruction, one of us (F. L. R.) found an area of ileum, which had apparently been traumatized at the time of the accident, bound down by fibrinous adhesions and kinked. Proximally the small bowel was hypertrophied for a short distance, so that some 12 inches were resected. The mesentery was very short, boggy and thick, and at one point in its root a small mass of dark colored material, either fecal material or old unabsorbed blood pigment, was found.

Pathologic study of the resected ileum showed the mucosa to be intact (Fig. 9p) with a heavy lymphocyte infiltration at its base extending into the submucosa which was greatly thickened and endematous, with fibrin deposits, clusters of lymphocytes and

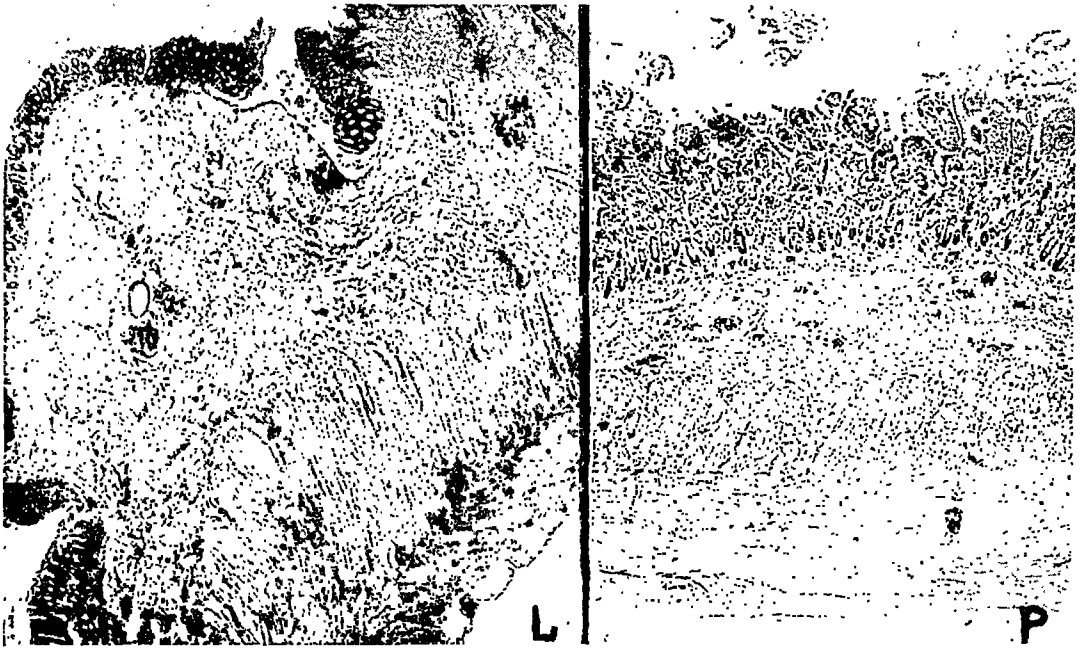


FIG. 9.—Case 2. L ($\times 12$). Chronic ileitis. Submucosa edematous and infiltrated with lymphocytes. Muscle layers greatly thickened and distorted with edema. Moderate lymphocytic infiltration. Serosa fibrinous and infiltrated with round cells. Lacteals engorged and many submucosal lymphatics thrombosed. Case 3. P ($\times 20$). Chronic ileitis. Submucosa greatly thickened and edematous, with clusters of lymphocytes and with engorged and thrombosed lymphatics. Muscles thickened and edematous. Lacteals engorged, with many thrombosed.

engorged and thrombosed lymphatic vessels. The muscles were quite edematous and thickened with infiltration by round cells and lymphoid tissue. The engorged lacteals between the muscle layers were prominent and many were thrombosed. The serosa was thickened by a heavy infiltrated fibrinous coat.

DISCUSSION.—From a careful gross and microscopic study of the specimens of regional enteritis and the specimens of chronic intestinal lymphedema produced experimentally, a definite and close similarity was seen. Although the pathologic changes were more pronounced in the human cases, yet, in both the clinical material and in the material experimentally produced by chronic lymphatic obstruction, the resemblance was marked in the pathologic alterations seen in the submucosal and muscular layers and in their lymphatic

vessels. No such resemblance had been obtained by Bell⁸ when he interfered with the blood supply of the intestinal tract in animals.

In our experiments the sclerosing material was injected only into lymphatics, and we feel that the pathologic changes resulting from such injections were due entirely to the lymphatic sclerosis and obstruction, since we found no evidence of blood vascular thrombosis in the microscopic sections.

The appearance of the gross specimens of regional enteritis and of experimental intestinal lymphedema, although varying in the degree of involvement, show the same thickened, edematous walls and microscopically greatly thickened muscular and submucosal layers which are edematous and have engorged and thrombosed lymphatics and lacteals.

The more extensive stenosis and mucosal ulceration seen in the human specimens might be attributed to the persistence of a chronic low grade bacterial infection. Our greatest thickening of the intestinal wall (Fig. 3) was secured when bacteria had been given intravenously shortly before the lymphatic injection.

It was surprising to find that months after such a lymphatic obstruction, although the animals appeared healthy, the pathologic alterations should persist and show no evidence of subsidence. Some of the animals, however, were sacrificed because of emaciation, or signs of obstruction due to the thickening of the injected bowel, or to adhesions kinking the bowel.

The surgical treatment of regional enteritis by resection of the involved portion of bowel is rational, since in the animal with chronic lymphedema, but without evidence of chronic infection, the pathologic alterations are apparently permanent.

SUMMARY.—Chronic lymphedema was experimentally produced in various regions of the gastro-intestinal tract.

This present report deals only with chronic lymphedema of the ileum and colon which was secured by injections into the mesenteric and subserosal lymphatic vessels of irritating and sclerosing materials.

Such lymphatic injections produced sclerosis and thrombosis of the lymphatics, which led to a chronic lymphedema.

Chronic intestinal lymphedema was secured by one injection, or by repeated injections.

Thickening and edema of the intestinal wall occurred and were most marked in the submucosal and muscular layers where the thrombosed lymphatics and lacteals were engorged with large pale mononuclear cells.

The injection of bacteria intravenously in conjunction with lymphatic injections produced the greatest thickening of the intestinal wall.

Intestinal lymphedema was found to persist for ten months without any evidence of subsidence and the pathologic changes appeared to be permanent.

In regional cicatrizing enteritis the thickening and edema were most marked in the submucosal and muscular layers, where engorged and thrombosed lymphatics and lacteals were found.

We believe that there is a close resemblance in the pathologic changes

seen in chronic regional enteritis and in experimental intestinal lymphedema.

The more extensive stenosis and mucosal ulceration in regional enteritis might be attributed to the persistence of a chronic low grade bacterial infection.

The two dominant features of regional cicatrizing enteritis seemed to be a low grade chronic infection with a concomitant chronic lymphedema.

The surgical treatment of chronic regional enteritis by resection has a rational basis, since experimental chronic lymphedema of the ileum and colon apparently is a permanent pathologic alteration.

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DISCUSSION.—DR. JOHN HOMANS (Boston, Mass.).—The experimental observations of Reichert and Mathes are particularly interesting to me because they have made use of what might be called physiologic methods in studying an important system of the body, namely, the lymphatic system,

particularly in its relation to a rather mysterious and interesting disease. As Doctor Reichert has stated, investigators have studied the blood-vascular system in similar ways for many years, but have neglected the lymphatics which, though we hear very little about them, are, after all, intimately concerned with drainage and detoxification of the tissue fluids in many parts of the body. Since a damming up of these fluids is very likely to lead to fibrosis, is it not reasonable that a peculiar state of swelling sclerosis and ulceration should be studied from the standpoint of lymphatic occlusion? Just as Cecil Drinker's methods of cannulating and destroying lymphatics have thrown new light on elephantiasis, or these experiments of Reichert's have suggested that regional enteritis, or whatever one chooses to term it, is dependent, in form, at least, upon lymphatic obstruction. Doctor Reichert has followed up his training with the late Doctor Halsted and with Doctor Sabin in a most ingenious way. I doubt whether others less skillful can produce similar results.

He has certainly shown how very readily edema and sclerosis of the bowel can be brought about by filling the lymph vessels of a region with a sclerosing medium. It is unfortunate that animals, particularly dogs, are so resistant to pyogenic bacteria. This resistance may retard the further verification of an hypothesis which Doctor Reichert has so modestly put forward, though of course he has shown how the presence of bacteria may fortify his results. In any case, he has done mechanically what nature probably does through the intestinal bacteria. Pathologically, regional enteritis is not an entity. Its variations may be due to a changeable exciting factor, for which Doctors Reichert and Mathes have supplied the anatomic background.

DR. ALFRED BLALOCK (Nashville, Tenn.).—I should like to speak very briefly of some experiments which I think corroborate the findings that have just been reported by Doctor Reichert. These studies were performed by Dr. R. S. Cunningham, Dr. C. S. Robinson and myself.

We were attempting to produce traumatic asphyxia, and we ligated the superior vena cava of a dog. Much to our surprise, nothing happened immediately. About ten days later the dog became short of breath. He died the following day, and at autopsy 900 cc. of milky fluid were found in the pleural and pericardial cavities. We thought possibly it was an accident and repeated the experiment on approximately 50 animals, and chylothorax resulted in more than one-half of them. We then wondered if we could produce lymphatic occlusion without venous obstruction. Complete lymphatic obstruction was produced in three of more than 50 animals studied, by a variety of procedures which included ligation of the ducts on the right and left sides of the neck, ligation of the thoracic duct in the chest, destruction of the cisterna chyli in the flank, and in some cases direct attacks upon the mesenteric lymphatics.

As was stated, we produced complete occlusion in three dogs. The evidence was this: The dogs lost weight. The eosinophils and the lymphocytes disappeared from the blood stream. Chemical studies revealed an abnormality in the absorption of fat. The dogs died, and at autopsy striking changes were observed.

In part of the intestinal tract from one of these three animals, the entire wall was perfectly white. Enormous lymph vessels were observed everywhere. Although the peritoneal cavity was not entered in this experiment, this condition resulted.

In a section of the omentum, large lymph vessels were seen. These were much more marked at the time of autopsy. In addition, there was a pooling of lymph in many of the tissues; for example, in the pancreas. The same

was true of the entire intestinal tract, and even occurred beneath the epicardium of the heart.

A section from a second experiment showed the lymphatics filled with coagulated material. Again the peritoneal cavity was not entered, showing that the same condition which Doctor Reichert can produce by a direct attack can be caused by operating elsewhere.

In the experiments in which complete obstruction was not produced, collateral lymph channels were demonstrated at autopsy. Most of these communications were with the inferior vena cava near the orifices of the renal veins.

DR. FREDERICK L. REICHERT (San Francisco, Cal.) closing.—Answering Doctor Homans' question about the acute cases of enteritis, I feel that certainly a number of them must recover from the condition without any symptoms, just as that last animal did, living for ten months without any symptoms whatever. Many of our cases probably do recover, but there are others, just as in this series of dogs, in which the thickening continued, some of them having obstruction and others developing adhesions and kinking and shortening of the mesentery. In none of our animals did we find any free peritoneal fluid.

Doctor Blalock's work is excellent. He too has produced thrombosed lymphatics and he has applied this method to the lymphatic system of the entire body. I will expect to hear a great deal more from him.

THE REDUCTION OF THE INCREASING MORTALITY AND MORBIDITY IN ACUTE APPENDICITIS

HUGH McKENNA, M.D.

CHICAGO, ILL.

DR. JOHN B. MURPHY was responsible for establishing a plan for the early diagnosis and immediate surgical management of this disease. Unfortunately, the Murphy plan has not been carried out by the general profession according to his original program. It may be of some interest to know that a few days before the death of Doctor Murphy, during a discourse on bone and joint surgery, he switched abruptly to the consideration of the present status of acute appendicitis, stating that: "Twenty years ago, I was of the opinion that we had taught the profession the vital importance of early diagnosis in acute appendicitis and the immediate treatment by surgery, but in this we have failed and I propose when I get back to work in September, to teach in my clinic, and write upon, the imperative necessity of early recognition of this disease, followed immediately by surgical management." The only charitable thing that may be said respecting delay in the surgical management of this disease is based upon the supposition that in the early period of the evolution of the treatment of acute appendicitis, there were areas where competent surgical services could not be secured. Whatever interpretation may be placed upon delay in action, a review of the literature shows that disastrous results have followed procrastination, in diagnosis and treatment, of this disease.

Until the medical profession makes an attack on the problem of acute appendicitis from a different point of view than has generally been done, no marked improvement will result. The work done by Bower and his associates^{4, 5} gives conclusive evidence of this fact. Most of the teaching and writing is occupied with the management and treatment of the pathology of a disease that should never occur. It seems just as illogical to attempt to improve the mortality rate in acute appendicitis by teaching how to handle extensive pathology, abscess formation and peritonitis, as it would be to go back to the period, before 1883, when Klebs discovered the bacillus of diphtheria, and to attempt any marked improvement in the treatment of diphtheria by refined methods of handling the pathology resulting from the disease rather than by preventing the stages of severe pathology.

The foregoing is not a parallel simile in disease types but it suffices for the purpose of calling the attention of the profession to the imperative necessity of attacking the problem of acute appendicitis in its inception and at a period when minimum pathologic changes have taken place. This program calls for much of the time and energy, utilized in teaching the methods used in treating the pathology caused in the late period of the disease, to be expended in an organized movement to make the lay people appendicitis con-

scious. Poor surgery, as demonstrated by the "occasional operator," much as that type of surgery may be deplored, is not responsible for the distressing rapidly increasing mortality rate in acute appendicitis.

When one reviews the voluminous literature on acute appendicitis he is impressed with the seriousness of this situation. However, when the mortality statistics taken from the U. S. Department of Commerce, Bureau of the Census, 1934, are reviewed the situation is not only serious but almost unbelievable (Table I).

TABLE I

THE DEATH RATE PER 100,000 ESTIMATED POPULATION IN THE REGISTRATION STATES OF
1900-1930

CAUSE OF DEATH — APPENDICITIS

1900	1910	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930
8.8	11.1	11.7	13.2	14.2	13.7	14.4	14.9	15.1	14.8	15.0	15.2	15.9	15.8

Statistics are usually uninteresting and writers usually try to avoid them, especially in papers. However, I shall attempt to give you a better idea of just what these figures mean: A mortality of 15.8 individuals in each 100,000 means 158 in each one million, and since in the United States we have a population of 122 millions, this means a mortality in this country of approximately 20,000 individuals dying each year from this disease and its complications. To more clearly visualize what this loss of life means, the dead would be approximately equal to twice the number of men in the Illinois National Guard. It is appalling to consider this tragic condition in a disease that should, under proper control, be brought to a small fraction of 1 per cent.

The foregoing narration does not take into account the morbidity in connection with acute appendicitis. What are some of the factors that lead to the increasing mortality in acute appendicitis in the United States? How does this compare with the death rate in other countries?

Again, quoting from Bower's statistics the incidence of appendicitis in the United States is:

TABLE II

59.3 per cent higher than the City of Mexico
70.0 per cent higher than Germany
70.0 per cent higher than Scotland
98.7 per cent higher than New Zealand
109.5 per cent higher than England and Wales
131.8 per cent higher than Irish Free State
313.5 per cent higher than Italy

Doctor Hoffman, consulting statistician of the Prudential Life Insurance Company, says: "During 1932 in 177 cities with a population of 43,021,704 there were 7,136 deaths, a mortality rate of 16.6 per 100,000." Still further he says, "In 1932 in ten of the largest cities of Pennsylvania, exclusive of Philadelphia, with a population of 1,474,567 there were 301 deaths, a mortality rate of 20.5 per 100,000. In 1931 these same cities with a population of

1,460,063 had 255 deaths, a mortality of 17.4 per 100,000. Philadelphia in 1931 with a population of 1,966,351 had 274 deaths, a mortality of 13.9 per 100,000; and in 1932 with a population of 1,978,663 there were 223 deaths, a mortality of 11.3 per 100,000." Bower⁴ from whose paper I quote these statistics, is of the opinion that the lowered mortality rate in Philadelphia is due to the campaign carried on in that city.

Etiology.—Geographic.—With Social and Individual Characteristics of Living.—If the mortality in appendicitis is to be reduced, consideration must be given to the comparative incidence of the disease in this country, as compared with other countries; some deductions may be made in the geographic factor by comparing the relative frequency of appendicitis in the white and black races. Boland³ reviewing 4,270 cases in Atlanta found that the disease was six times as common in the white as in the colored race. Commenting upon the relative infrequency of appendicitis among colored people, he draws attention to the report of McCarrison, in India, where the disease did not occur among several thousand patients who lived upon "natural foods" free from preservatives. Most Negroes in the south live on cornbread, peas, cabbage and turnip green juice (pot likker). Thirty years ago appendicitis was almost a novelty among these people, but as they gave up simple food the disease has increased, according to Boland. The factors pointed out in this review may explain the increased incidence of the disease in the United States as compared with the countries referred to in Table II.

Age Incidence.—Appendicitis is primarily a disease of the young, the greatest incidence between the ages of 11 and 20, although it may occur at any age. Hudson¹⁹ shows that "in Massachusetts appendicitis was recorded as the cause of death in 1,795 children from 1900 to 1930. In 1900 the diagnosis was recorded 25 times, and in 1930 107 times. This represents an increase of 428 per cent in a period in which the population increased only 41 per cent." According to his report appendicitis held eighth place as a mortality factor in children.

Habits of life and foods leading to constipation.

The homogeneous factor in connection with acute tonsillitis, and upper respiratory tract infections, in my opinion, has not received sufficient consideration. Other foci of infection should not be overlooked.

Symptoms and Diagnosis.—Wilkie has directed attention to a point in differential diagnosis between the acute inflammatory and the obstructive form. In brief, he describes the obstructive form as coming on with severe cramps, usually violent in character, followed by nausea or vomiting, with usually repeated colicky attacks. The inflammatory form he describes as coming on with the symptoms of malaise, without sharp pain. He considers the obstructive type as the more serious condition.

In a fairly extensive experience in acute appendicitis during the war it was interesting to note that with medical officers drawn from many parts of the country, few of them were trained in the importance of securing a history of symptoms in sequential order. Acute appendicitis begins *with pain*

and as a rule up to 18 hours the pain is referred to the pit of the stomach, finally localizing in the region of the appendix which in the large percentage of cases is in the lower right quadrant of the abdomen. Diagnosticians should not overlook the fact that the appendix may be in other regions of the abdomen: namely, (a) the epigastric region, (b) anywhere in the left abdominal region, (c) and not infrequently in a position immediately in front of the right kidney. In this latter position it not infrequently leads to a diagnosis and formation of a perinephritic abscess. (d) The appendix may be found in any of the normal openings of the abdominal wall, such as the inguinal or any other hernial opening.

In the second attack nausea or vomiting or both may be absent. I have already published what I believe to be the reason for the absence of these symptoms, namely, the fixing of the cecum by the inflammatory reaction consequent to the first attack.

Leukocytosis is an important factor if properly interpreted. Keep in mind that the white count may be positive or only relative. As I previously demonstrated in a report, with Morris, on 234 soldiers operated upon at Camp Pike Base Hospital, the white count was only relatively high. We concluded that since these soldiers had received typhoid and paratyphoid vaccine, previous to the attack of appendicitis the blood would show a leukopenia. We ran a control upon 100 soldiers in normal health, who had previously received inoculations of typhoid and paratyphoid vaccine, and demonstrated that a leukopenia existed. It was evident therefore, that when these individuals suffered an attack of acute appendicitis an increase to 8,000 white cells would represent a relative leukocytosis. With an initial white count of more than 22,000, careful search should be made to find a possible cause outside the appendix, particularly the possibility of a pneumonic process.

Temperature may be increased at the beginning but not necessarily so, and absence of temperature should not mislead one in making the diagnosis. Later when the inflammatory process is well established or is spreading, the temperature curve is of importance. The pulse rate is not necessarily of diagnostic importance at the onset.

I have not found rigidity of the abdominal muscles of importance in the very early hours of the attack during the most favorable period to make the diagnosis. One should never fail to make a rectal examination, especially in children. I have always considered this of importance in children in making a differential diagnosis between appendicitis and possible pneumonia.

Morbidity and Pathology.—Morbidity is so dependent upon pathology that these subjects are treated conjointly. In Wilkie's investigations, unquestionably, a point was made in differential diagnosis based upon the pathology in the appendix. The obstructive type, made possible in many instances because of a previous inflammatory condition, produces an attack through the formation of a fecalith distal to a constriction near the base of the appendix, which cannot pass and in this position rapidly cuts off the blood supply. A similar pathologic change may be brought about by a con-

ACUTE APPENDICITIS

stricting band at or near the base of the appendix. I trust the teaching of Wilkie may not lead to any delay in the surgical management of the acute inflammatory type of appendicitis. In the first place, the differential diagnosis may not always be made and, at any rate, the inflammatory attack makes the pathologic change upon which the obstructive type is formed.

Treatment will be considered under the following heads:

(1) Education of the people of the possible seriousness of pain in the abdomen, especially in the young.

(2) A campaign in the medical profession on the necessity of immediate hospitalization of patients suffering with pain in the abdomen where a tentative diagnosis of appendicitis is made.

(3) The type of treatment to be instituted.

Thanks to the efforts of Bower, the mortality of acute appendicitis has been greatly reduced due to the campaign carried out in Philadelphia. In brief, the plan consisted in making the public appendicitis conscious by a publicity campaign. Through the Philadelphia Association of Retail Druggists the following placard was placed in most of the drug stores of that city:

APPENDICITIS

SEVERE PAINS IN THE ABDOMEN ARE OFTEN
DANGEROUS. DO NOT TAKE PURGATIVES. CALL
A PHYSICIAN. DEATHS FROM APPENDICITIS ARE
INCREASING ANNUALLY.

In addition, these placards were sent to family physicians. Recognizing the greatest incidence of the disease between the ages of 11 and 20, talks were given in schools and sticker placards sent them directly to be posted in their school books. Under the head of warning they issued the following placard:

WARNING

IN THE PRESENCE OF ABDOMINAL PAIN:
NEVER GIVE A LAXATIVE.
GIVE NOTHING BY MOUTH.
APPLY ICE CAP OR WATER BOTTLE.
CALL YOUR FAMILY PHYSICIAN.
ABDOMINAL PAIN WHICH LASTS MORE
THAN SIX HOURS IS USUALLY SERIOUS.

The Philadelphia plan was published by the Philadelphia County Medical Society and endorsed by the Department of Health. The plan was given much publicity and, by lectures to the laity, an attempt was made to show the relative seriousness of the clean and peritonitis case.

Recommendations.—(1) That a plan similar to the Philadelphia campaign be instituted by every county medical society, using every legitimate avenue

open to organized medicine to reach the public respecting the seriousness in delay in recognizing and treating acute appendicitis.

(2) Give more attention to this subject in undergraduate teaching. Arrange to have a paper on this subject before every branch society annually. Invite all hospital staffs to check the annual death rate from acute appendicitis with the hope that the community, both lay and medical, may become appendicitis conscious.

(3) The treatment is surgical in the large percentage of cases. Dixon, of the Mayo Clinic, has expressed the belief that "the increase of deaths from appendicitis is due to three factors, two of which concern the medical profession, while the third concerns the unfortunate widespread use of cathartics by the patient with appendicitis." Dixon believes that more patients with appendicitis have been operated upon by the "occasional operator" during the past ten or 12 years; he also suggests that the present generation of younger surgeons has not taken seriously the wide experience of the older surgeons in this field. The tendency of some physicians to regard appendectomy as a minor surgical undertaking should be universally condemned. There is no operation in the whole realm of major surgery which may demand greater exercise of surgical skill and judgment.

When I say the treatment is surgical I do not wish to say that in the pus or local peritonitis cases that the same surgical procedure should be followed that obtains in the clean cases. I am firmly of the opinion that if a reduction in the mortality is made in the late cases, where rupture has taken place, it must come in determining first the cases that should be operated upon, and secondly, the type of operation to be instituted.

There is no doubt that many patients diagnosed as progressing peritonitis or general peritonitis have only localized peritonitis, and in many cases this cannot be determined without operation. In these borderline cases, to make a small opening under local anesthesia and introduce a drain should not add to the mortality. On the other hand, even through a small opening, without introducing anything into the peritoneal cavity, a localized peritonitis may many times be diagnosed and the pus drained, and a general peritonitis prevented.

In the cases with a localized abscess I have always attempted the plan of entering the pus cavity without entering the free peritoneal cavity. This can be done only in a small percentage of the pus cases. In all other localized pus cases the surgeon can wall off the peritoneal cavity in a thorough and systematic manner, so that the pus may be evacuated and gently sponged out with gauze sponges soaked in one-half of one per cent lysol solution, drains inserted to the bottom of the cavity, and the omentum carefully drawn around the drain and the wound closed. This procedure can usually be carried out without the introduction of anything into the free peritoneal cavity by the moist sponges put in position before the pus cavity is opened. I follow the rule of taking the appendix out in these pus cases when the line of cleavage through which the pus cavity is entered leads to the appendix. In

this procedure the appendix may be removed without soiling the free peritoneal cavity more than in the drainage operation. In the large percentage of cases the ruptured appendix should be removed, which in my opinion if taken out by the plan outlined does not increase the mortality, and decreases the morbidity.

An entire paper might be advantageously given to a detailed discussion of many special methods of treatment, such as high enterostomy, introduction of a catheter into the cecum, Fowler's position, with a "rectal drip" of normal saline solution by means of a properly arranged douche tip.

At Camp Pike, during the war, I was able to get the Division Surgeon to issue an order that all soldiers suffering with abdominal pain, that persisted, be sent to the hospital. In approximately 450 operations upon soldiers, the large percentage of which were for an acute appendicitis, the mortality rate was markedly reduced, and the fatalities that occurred were due to either an inability to gain consent to perform the operation, or to some complication.

The morbidity and mortality in acute appendicitis will be reduced when the disease is brought to operation within the first few hours following the initial attack. In the doubtful cases call a consultation early in the disease, and if the diagnosis cannot be made, err on the side of surgical intervention.

Sufficient attention has not been directed to appendicitis developing in unusual locations in the abdomen, and particularly that which, because of location, becomes the etiologic factor in perinephritic abscess.

ABBREVIATED, ILLUSTRATIVE CASE REPORTS

Case 1.—Mr. R. entered St. Joseph's Hospital giving a history of having been operated upon for a right perinephritic abscess one year previously. A permanent fistula, discharging pus, followed this operation. A thorough examination of the genito-urinary tract revealed no connection with the fistula. A barium enema demonstrated that the fistula was connected with the right colon. An abdominal operation disclosed an old ruptured retrocecal appendix lying on the anterior surface of the right kidney. The remnant of the appendix was removed and the patient made an uneventful recovery, almost 15 months following the original attack of appendicitis. Consider if you will the economic waste caused by a mistaken diagnosis.

Case 2.—A young male patient was brought into the receiving ward of the Cook County Hospital. The receiving intern, a student, announced in the clinic that if my teaching was correct this patient had appendicitis, although his physical symptoms were those of a perinephritic abscess. Basing the diagnosis principally upon the history the patient was operated upon immediately for acute appendicitis. When the cecum and base of the appendix were exposed these structures appeared normal. However, as the appendix was traced back in its retrocolic position and freed from adhesions, the tip passed for a distance of one and one-half inches through and behind the retroperitoneum. Cutting through this structure the distal end of the appendix was found with a necrotic wall and abscess formation, and containing a fecolith, the mass lying just anterior to the right kidney. Had this young man not been operated upon immediately a perinephritic abscess would have formed and a subsequent operation in the lumbar region would have corroborated the wrong diagnosis just as in the first case cited.

Case 3.—A boy, aged 17, the son of a physician and the grandson of a noted medical teacher, was admitted to the hospital after an illness of about five weeks. A number of the leading specialists of the medical school in which the grandfather had taught had seen this patient. There was a very classical history of appendicitis recorded, but on

TABLE III
CASES OF APPENDICITIS — ST. JOSEPH'S HOSPITAL
1922-1935

Diagnosis	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	Total
Appendicitis, acute.....	35	32	36	42	58	48	50	76	79	78	62	49	77	55	777
Appendicitis, gangrenous.....	22	24	27	33	39	35	31	25	22	30	34	18	33	45	418
Appendicitis, chronic.....	82	73	67	80	116	104	102	93	89	97	73	56	63	56	1,151
Appendicitis, subacute.....	16	22	23	18	17	25	29	35	23	26	17	16	31	32	330
Appendicitis with peritonitis.....	6	7	7	4	6	7	4	3	4	3	1	3	2	5	62
Appendicitis. Incidental appendectomy....	35	39	22	30	36	40	37	37	54	40	18	24	19	18	449
Total.....	196	197	182	207	272	259	253	269	271	274	205	166	225	211	3,187

Total deaths, 78; mortality, 2.48 per cent.

APPENDICITIS — DEATHS FOLLOWING OPERATIONS — 1922 TO 1935

Appendicitis, acute suppurative.....	9	Appendicitis, chronic.....	12
Appendicitis, gangrenous, ruptured.....	36	Appendicitis, subacute.....	2
Appendicitis, gangrenous, with peritonitis.....	15	Appendix, incidental—cyst of ovary.....	1
Appendicitis, with abscess.....	3	Total.....	78

CAUSES OF DEATHS

Dilatation of heart, acute.....	1	Pneumonia, broncho.....	1
Embolism, pulmonary.....	4	Pneumonia, lobar.....	4
Myocardial failure, acute and shock.....	1	Psychosis, acute exhaustion, and hypostatic pneumonia ..	1
Myocarditis and nephritic, chronic.....	1	Parotitis, bilateral, septic with meningitis.....	1
Myocarditis, chronic.....	1	Septicemia.....	2
Obstruction, intestinal, acute.....	1	Septicemia and myocarditis with multiple emboli.....	1
Paralysis, cardiac, following embolism.....	1	Shock, surgical.....	5
Paralytic ileus.....	17	Toxemia and pneumonia.....	1
Peritonitis, general.....	34	Total deaths.....	78

Mortality, 2.48 per cent; total cases, 3,187.

physical examination the pain was very low down in the pelvis and on the left side. As a result the diagnosis was not made. On the morning the patient entered St. Joseph's Hospital in the fifth week of his illness, in order to complete the physical examination a roentgenologic examination was made of the chest. This was negative. In a few hours following admission the patient had a sudden, severe, explosive coughing attack, with rapid respiration, increased pulse rate, elevation of temperature, and in short the signs of marked chest pathology, which the physical findings and the subsequent roentgenogram corroborated. The patient developed a pneumonia followed by empyema and a long drawn out convalescence, being confined to the hospital approximately three months. At the time of discharge from the hospital the father was instructed in the event of abdominal pain to immediately bring the patient to the hospital for surgical treatment.

Approximately six weeks following his discharge, the patient had an attack of abdominal pain. He was hurried to the hospital and an emergency operation was performed. Through a lower left rectus incision a necrotic appendix was removed from a bed of old adhesions on the left side of the pelvis in the rectovesical cul-de-sac. Recovery was uneventful. Consider what this patient went through—his suffering, serious condition, expense, and loss of time—all because a correct diagnosis was not made in the first few hours of the disease and the inflamed appendix removed.

The recitation of these three cases illustrates the pathology which may result from acute appendicitis, where the patient, although seen early by a physician, was not correctly diagnosed, and was not afforded the relief which immediate operation would have effected.

Doctor Murphy, who continued to teach the imperative necessity of early diagnosis and immediate operation in the treatment of acute appendicitis, made the following comment April 7, 1915: "Just recently a critic took a Chicago surgeon to task in the columns of a medical journal because the latter had published a colored picture of a gangrenous appendix in connection with a practical talk on the proper treatment. The critic intimated that appendicitis was ancient history. It is ancient history; but does that statement mean that all practitioners are masters of the subject, or that the disease is efficiently handled at the present time?

"In looking up recently for the Year-Book of Surgery the hospital statistics on the results of operation for appendicitis, what mortality rate do you suppose I found—the hospital mortality rate? Someone guess! I do not mean the mortality for one, two, or three splendidly equipped hospitals, with staffs composed of the leaders of the surgical profession; I am speaking of the combined statistics of a number of hospitals in the United States. That average hospital mortality rate is just a little over 10 per cent!

"Is it time to stop talking about appendicitis? No! It is just the time to begin talking about appendicitis, and talking more seriously and emphatically about it. When you know that in our best hospitals better than 98 per cent of all the acute appendicitis cases, including those with abscess and peritonitis, are saved, and when you know that scarcely one out of a hundred of the cases of acute appendicitis operated upon during the first 24 hours of the attack is lost, I think what the results must be in the other hospitals to make the general average so appalling. There is no palliative excuse for a mortality of 10 per cent in appendicitis. That rate is simply shocking. Even cases of

appendicitis with perforation into the free peritoneal cavity have now but a very slight mortality when operated upon in time by experienced hands; and still the appalling combined rate is 10 per cent, including the chronic and interval cases—which should show practically no mortality at all—as well as the acute cases. These patients did not die because of the operation—they died in spite of it. They died, not so much because of any fault in technic as, because of the fact that they did not reach the hospital in time for a successful operation. Procrastination was the cause of death—the almost criminal cause. The initial symptoms are clean cut and almost unmistakable. The mode of onset of an attack of appendicitis is no clue to its probable course or complications. We can never tell in a given case what the next day may bring. Therefore, operate today. By operation we take the course of the disease into our own hands. By not operating we leave the case in the hands of a blind and often terribly cruel fate.”

After reviewing hospital statistics showing the mortality statistics in acute appendicitis following various methods of classification, it was interesting to review the report from St. Joseph's Hospital, Chicago. In this hospital for many years the watchword has been “early diagnosis in acute appendicitis and treat immediately by surgery.” The following report on 3,187 cases includes all operations where the appendix was removed, 1922 to 1935 inclusive, acute, chronic and incidental. These operations were performed by staff and nonstaff members.

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RESECTION OF THE RECTUM AND RECTOSIGMOID BY SINGLE OR GRADED PROCEDURES

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THE routine application of stereotyped technical procedures to any pathologic process, especially if that process be a malignant one, should be and is discountenanced by all experienced surgeons. Nowhere is this more forcibly emphasized than in the selection of surgical measures for the radical extirpation of cancers in the lower gastro-intestinal tract.

That no one type of offensive meets the requirements of all cases is axiomatic, but it is, or should be, equally true that the majority of these cases should be operated upon by as radical surgical procedures as are compatible with a reasonable hospital mortality. To increase the scope of operability is as imperative a duty as to reduce the hospital casualty list, and to this end several surgical operations either in one or more stages must be included in the surgeon's campaign plans.

Statistical studies by Miles, Jones, and others have proved incontrovertibly that the application of the same principles of surgery to cases of cancer of the rectum as to cases of cancer of the breast, lip, *etc.*, yields immensely higher percentages of five year cures than the less extensive procedures. That the radical operative maneuvers may not be applied to all cases of cancer of the rectum which are deemed operable and that they cannot be applied always in the ideal operative method, is, I think, hardly debatable. Consequently, while one deprecates multiple surgical procedures, particularly those which demand reopening of the abdomen at a second stage when one operation will accomplish the same result, there is small question that a field does exist not only for the graded radical extirpative procedures, but also for the less formidable operation of colostomy and posterior resection.

The choice of offensive against cancer of the rectum and rectosigmoid, viewed from the operative standpoint as well as from the standpoint of end-results, is, in my judgment, the one stage combined abdominoperineal resection of the rectum following the technic of Mr. Ernest Miles. That the mortality figures of this type of operation cannot be reduced beyond a range of 5 to 10 per cent even in the most experienced hands, without a too noticeable reduction in operability rate, will, I think, be admitted. Its mortality rate has been the one objection to the operation, but I am convinced that this objection is no longer defensible because of the low mortality statistics of experienced surgeons which my own recent experience in a series of 22 cases operated upon without mortality supports.

More familiarity with technical details and more meticulous preoperative and postoperative care have allowed me to utilize this one stage maneuver in a higher percentage of cases than hitherto. That this ideal may not be

carried out in many cases where the rectal tumor is removable, yet hazardously so because of complicating coexisting debilitating diseases and the patient's inability to stand formidable operative procedures, is quite evident.

For the less sturdy risks—and this is a fairly numerous group of cases—I feel that a two stage maneuver of the type advocated for many years by Daniel F. Jones, or the technic of a graded radical combined abdomino-perineal resection, which in reality is a modification of Miles' technic into two stages, as described by me² in 1929, has a definite field of usefulness. In this maneuver the bowel is divided, turned in, the distal segment dropped back, and a single barreled colostomy made in the left flank. Lahey one year later modified my operation by bringing out the lower end of the bowel and using it to irrigate through. I have not utilized this procedure because I have felt that if obstruction was present one divided the bowel at a greatly increased hazard and if obstruction was not present in a marked degree, one could irrigate with a two way tube in the rectum just as satisfactorily.

This two stage operation, I am confident, has allowed me to perform a radical operation in many cases where the growth was so large and inflammatory or where the patient's condition was so debilitated and undermined that a single stage operation would have been attended by a prohibitive mortality whereas the only other choice was a colostomy and subsequent posterior resection.

That the graded operation can be done in this group of cases to possibly extend the operability with the same or slightly lower operative mortality, is my belief. Nevertheless, I must confess that within the past two years my own experience with the one stage operation has led me to substitute it in an increasing number of cases, to the virtual abandonment of other types except under the circumstances mentioned above.

The second variety of graded maneuver which still holds a place in surgery for cancer of the rectum is the operation of Mummery—that is, colostomy and subsequent posterior resection. That this operation does not remove the lymphatic nodes of the sigmoid mesentery and that it is far from being a radical type of procedure, one cannot deny, yet it can incontrovertibly be carried out in a group of cases which are such grave operative risks that the radical procedures are not to be considered, and with five year cures of 38 per cent as I³ showed in reviewing 300 cases.

Because of slow metastases from rectal cancer, those occurring in the ampulla unquestionably can many times be operated upon successfully by this latter method, but there is small question that a statistical study of the end-results will show a much lower percentage of five year cures if this type of operation is routinely employed, especially in the rectosigmoid cases.

The indications for a two stage operation are, I think, defined by first, the patient's general inability to withstand a formidable surgical procedure; second, local complications such as an unusually large tumor with little mobility, or fixation to adjacent viscera; third, cases requiring double resection of large and small bowel or bladder; fourth, anatomic types such as extreme

obesity; fifth, coexisting debilitating diseases such as diabetes and cardiovascular diseases; and sixth, extreme old age.

Given a movable growth in the rectum or at the rectosigmoid in an individual without coexisting complications and an average operable risk from a general standpoint, the operative choice is the one stage combined abdominoperineal resection. For the above mentioned exceptions the two stage combined and the colostomy and posterior resection offer a distinct chance for palliation or cure to a definite group.

In the past three years in my own experience, six changes in operating upon rectal and rectosigmoidal cancers have been established. These are: first, elimination of intraperitoneal vaccination as a routine step in the preliminary preparatory period; second, the abandonment of spinal anesthesia; third, an extension of the period of preparation to at least seven days; fourth, the routine performance of a presacral neurectomy; fifth, routine blood transfusions postoperatively; and sixth, the adoption of the one stage combined abdominoperineal resection in a higher percentage of cases than hitherto.

Intraperitoneal Vaccine.—In 1928, at my suggestion, Herman did some experimental work in Mann's laboratory with intraperitoneal vaccine of colon bacillus and Streptococci, which prompted us to use it routinely in the preliminary preparation of patients operated upon for organic lesions of the large bowel and rectum. Subsequently, after utilizing this vaccine in a series of 60 cases, Bergen and I reported favorable declines in operative mortality statistics, and a smoother postoperative convalescence.

While it was recognized that this was only one of a series of advantageous steps in the rehabilitation of these individuals with colonic and rectal lesions preoperatively, we felt that it had a large sphere of usefulness, and in a further report on vaccination against peritonitis in surgery of the colon we reported a series of 300 cases in which the some favorable outcome influenced us to credit the vaccine with being a large factor in the mortality decline. In a review of 527 surgical lesions of the large intestine and rectum which I published in 1930,⁴ the mortality rate was 12.3 per cent by patient and 8.6 per cent by operation.

In February, 1933, I began a series of operations for organic lesions of the colon and rectum in which the preoperative vaccination was not utilized. Table I shows the diagnoses of 130 cases of organic lesions of the rectum and colon which were operated upon in this series without the use of preliminary intraperitoneal vaccine:

TABLE I
DIAGNOSES IN SURGICAL DISEASES OF THE
ILEUM, LARGE INTESTINE AND RECTUM

	Patients	Deaths
Cancer.....	95	8
Diverticulitis.....	5	0
Intestinal obstruction.....	5	0
Ulcerative colitis.....	4	1

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TABLE I—*Continued.*

	Patients	Deaths
Megacolon.....	4	0
Polyposis.....	4	0
Fecal fistula.....	2	0
Tuberculosis.....	2	1
Inflammatory cecal tumor.....	2	0
Intussusception.....	1	0
Miscellaneous conditions.....	6	1
	<hr/> 130	<hr/> 11

Mortality by patient—8.4 per cent.

In 200 consecutive operations done on these 130 patients there were 11 deaths, a mortality of 5.5 per cent by operation, and 8.4 per cent by patient. The pathologic conditions, operative technic, and operability rate utilized in this series were identical with the former series. Table II shows the types of operation done in this series of cases and indicates that both the diagnoses and operations parallel those published in 1930:

TABLE II

TYPES OF OPERATION ON THE COLON AND RECTUM IN 200 CASES

	Operation	Death
Combined abdominoperineal resection, one and two stages.....	23	0
Posterior resection and colostomy.....	40	1
Colostomy alone.....	13	4
Obstructive resection.....	16	2
Resection right colon.....	10	0
Ileocolostomy.....	15	2
Exteriorization (graded).....	33	1
Sympathectomy.....	4	0
Colectomy.....	3	1
Cecostomy.....	13	0
Ileostomy.....	6	0
Enterostomy.....	2	0
Closure of or plastic on colostomy.....	9	0
Abdominal exploration.....	3	0
Miscellaneous.....	10	0
	<hr/> 200	<hr/> 11

Mortality by operation—5.5 per cent.

This series of cases has convinced me that the decline of the mortality rate under cooperative management which included intraperitoneal vaccination was due more largely to the other rehabilitory and decompressive steps than to vaccine.

That peritonitis is the most common lethal factor following major operations for organic lesions of the large bowel and rectum is a common observa-

tion in all autopsy statistics, and logically one must concede that any measure which increases the resistance of the peritoneal tissues is desirable. That further research will confirm this opinion is an earnest hope, but the present evidence seems to point largely to the question of decompression, hydration, and general rehabilitary measures as the most potent factors in increasing resistance to intraperitoneal infection.

Anesthesia.—Elimination of spinal anesthesia in my service has not been with any regret. While spinal anesthesia has many advantages to the surgeon and perhaps to the patient as well, the inability to control it and occasional surgical accidents have commonly been the reasons for its abandonment.

The ideal anesthetic remains to be evolved but I have found great comfort in the use of gas-oxygen and ether where the one stage operation is decided upon, and gas-oxygen and ether for the first stage of the two stage operation while transsacral and gas-oxygen have been employed in the second stage of the graded maneuver.

With better preliminary medication and better administration of anesthesia, the margin of safety has been unquestionably increased, yet the disappearance of pulmonary complications remains a hope rather than an achievement.

Presacral Neurectomy.—For the past two years I have routinely performed a presacral neurectomy after either the one or the two stage resection has been completed. There are two reasons for this: first, to influence the atony of the bladder; and second, for relief of pain in the event of pelvic recurrences.

The abdominal part of the abdominoperineal resection is a very extensive dissection and there is small wonder that, in cleaning out the fat and soft tissues both from the lateral pelvic walls and the hollow of the sacrum, even greater injury is not done to the nerve supply of the bladder. It is a common experience that complications in the urinary tract following the bladder atony and necessary catheterization are of quite serious import.

Learmonth's¹ work on the innervation of the urinary bladder and his resection of the presacral nerve in the treatment of cord bladder and certain other types of atonic conditions with benefit, pointed logically to the presacral neurectomy as an advantageous step following rectal resections. He found that normal bladder activities are controlled by three chains of nerves, namely, the sacral autonomic, the thoracolumbar outflow of the sympathetic system, and the somatic centers in the sacral part of the spinal cord. Each of these systems contains afferent and efferent fibers. The nerve is easily accessible as it passes in front of the fifth lumbar vertebra, and following ligation of the inferior mesenteric artery with the bowel pulled forward and the peritoneal flaps mobilized, it is a simple matter to ligate the middle sacral artery and then sweep the tissues in front of the sacrum across over the left common iliac vein and upward toward the inferior mesenteric stump.

I have felt that there was a distinct improvement in the emptying of the bladder and a consequent lessening of urinary complications following its utilization. The most reasonable explanation of the success of neurectomy seems to be that the hypogastric nerves in man carry inhibitory impulses to the bladder which may be sufficient to prevent its complete emptying when these nerves are intact and the pelvic nerves are injured.

The reported results of sympathectomy carried out for the relief of pelvic pain seem to indicate that the same procedure would be useful for pain of recurrent malignancy. There is some controversy among neurologists as to the mechanism by which this is accomplished, the only proved contribution of the autonomic nervous system to pain being in relation to referred pain in the production of which only efferent fibers are utilized.

The fact seems well established that pain impulses are mediated along the hypogastric plexuses, and whether they are transmitted over the autonomic nerves or pathways belonging to the spinal nerves is immaterial if by sectioning the hypogastric plexuses the painful impulses can be interrupted and the intense pain of recurrent malignancy prevented.

Blood Transfusions.—Following resections of the colon or rectum, regardless of the type, it has been our custom within the past two years to give a routine blood transfusion of 500 cc. of citrated blood. The physiology upon which this step is based is not clear, but the impression that it is most desirable is confirmed by the smoother convalescence, the absence of any delayed reaction, and the general improved outlook in the cases in which it has been utilized.

Resections of the colon and rectum are not shocking operations if they are done meticulously with accurate hemostasis and on properly selected cases. These people leave the operating table not in collapse, but with a good pulse and blood pressure, and react promptly from the anesthetic in the majority of instances. That the blood transfusions probably tide them over the period where delayed reaction of a mild or even mildly serious nature might take place in the first six to twelve hours, is, I think, an apt hypothesis. That the mobilization of certain chemical substances follows operative procedures on the large bowel and that this is taken care of by the blood transfusions, is another theory which I am not able to debate, but the confirmed opinion that routine transfusions is distinctly desirable following colonic and rectal resections, is definitely borne out in my experience.

Table III indicates the trend in my service toward the one stage operation during the past three years. Clearly, however, there is an indication for an occasional two stage operation which embodies the features of the one stage radical procedure. Again, there is a very definite proportion of cases which cannot be submitted to either of the formidable combined procedures but which can be operated upon by the colostomy and posterior type of operation of Mummery.

TABLE III

CANCER OF THE RECTUM AND RECTOSIGMOID

50 Cases

Resections.....	38
Explorations.....	12
Operability.....	76%

TYPES OF RESECTION

One stage combined abdominoperineal (Miles).....	18
Colostomy and posterior (Mummary).....	16
Two stage combined abdominoperineal (Rankin).....	4

MORTALITY

Mortality—Total group (50 cases).....	5
Following colostomy and posterior resection.....	1
Following colostomy alone.....	4
Causes of death—Pulmonary embolus.....	2
Coronary occlusion.....	1
Peritonitis.....	1
Intestinal obstruction (acute).....	1

CONCLUSIONS

It has seemed advantageous to me in the past three years to make the following changes in the handling of cases of cancer of the rectum and rectosigmoid: first, the abandonment of intraperitoneal vaccination as a preliminary preparatory step (the elimination of vaccination has been done with regret and with the hope that some utilizable step in this direction may be found in the future); second, the elimination of spinal anesthesia as a routine anesthetic; third, an extension of the period of preparation to at least seven days; fourth, the routine performance of a presacral neurectomy; fifth, postoperative blood transfusions; and sixth, a wider use of the single stage abdominoperineal resection after the technic of Miles.

Even though the ideal operation is a radical resection in one stage, there is small question that a definite field for a radical procedure by graded maneuvers exists. Unquestionably, there are cases which are considered borderline for surgery which may be advantageously operated upon by a two stage radical maneuver, thus increasing the operability percentage without increasing the mortality statistics. Furthermore, the conclusion is inescapable that there are many cases upon whom it is impossible to employ either of these radical procedures and yet in whom resection may be undertaken by a less formidable operation, namely, colostomy and posterior resection.

With the statistical data available to prove that from 38 to 79 per cent of cases of cancer of the rectum and rectosigmoid may be given a chance of five year cure by the utilization of either the one or two stage combined operation, or the less radical colostomy and posterior resection type of maneu-

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ver, the hopeful prognosis following surgery for cancer in this location is definitely established and the indications for the different types of surgical operation are rapidly becoming more and more clearly recognized.

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THE ONE STAGE PROCEDURE OF THE TREATMENT OF CARCINOMA OF THE RECTUM

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FOR many years carcinoma of the rectum was treated in this clinic by a variety of methods, depending upon the opinions of a number of different surgeons. The results were variable but in the main unsatisfactory. The operative procedures directed to a local removal had a low operative mortality but also a very low incidence of cure, while the more extensive operative procedures had a high operative mortality but a higher percentage of cures. On considering the situation it was obvious that we were learning slowly, and by bitter experience, a lesson that had been taught clearly and with finality by Miles.¹ His brilliant and painstaking investigation of the lymphatics of the rectum, his observations on the mode of spread of carcinoma of the rectum, and his study of end-results of all types of operative attack were so conclusive that we felt it imperative to base our treatment on his conclusions.

From 1931 to 1936 we have endeavored to follow his teachings and methods in treating carcinoma of the rectum and it is with our personal experience during this time that we wish to deal here. No two clinics have the same cancer problem, which varies with the social and economic status of the patients treated in that clinic. In the University Hospital, the majority of the patients come when they are incapacitated, which means that, by and large, patients with cancer are seen here late in the course of the disease.

During this period we have had the opportunity of studying 270 patients with carcinoma of the rectum or rectosigmoid. Of these, 183 were men and 89 women. Forty-six patients came for diagnosis only, or refused operation, or were treated elsewhere, leaving 224 patients receiving treatment in this hospital. The age distribution of the patients corresponds with that of other cancer groups. The diagnosis was proven in every case by examination of biopsy or operative specimen and the tumor types correspond to the usual findings in this group of patients. After examination it was found that 114, or 51 per cent, of those entering the hospital for treatment were unsuitable for radical operation because of the far advanced lesion or because of associated disease. An analysis of the treatment carried out for these patients is shown in Table I.

Some in the terminal stages of the carcinoma, often with widespread metastases or with advanced other disease were not given any treatment for the carcinoma. Another small group was treated by roentgen therapy, radium or electrocoagulation; this includes patients with squamous cell carcinoma

of the anal canal, for whom we advise irradiation therapy. Palliative colostomy was performed on many for the reasons shown in Table II.

TABLE I

PATIENTS UPON WHOM RADICAL OPERATION WAS NOT ATTEMPTED	
Unsuitable for radical operation.....	114 = 51%
No treatment advised	
Terminal stage with widespread metastases.....	12
Far advanced other disease.....	4
Palliative operation	
Colostomy.....	75
Colostomy before entrance.....	10
Radium and roentgen therapy.....	2
Electrocoagulation.....	2
Cystostomy.....	2

TABLE II

REASONS FOR PALLIATIVE COLOSTOMY ONLY	
Performed elsewhere.....	10
Colostomy in hospital.....	75
(a) Local extension to peritoneum, bladder, prostate, vagina, fistulae.....	43
(b) Local lesion operable but metastases in liver.....	11
(c) Locally inoperable with liver metastases.....	15
(d) Metastases in inguinal nodes.....	1
(e) Age.....	5

The largest number were unsuitable for radical operation because of local extension of the carcinoma to the viscera lying adjacent to the rectum. Direct infiltration of the bladder, uterus, broad ligaments, vagina or prostate, or infiltration of the peritoneum of the pelvic floor, rectovesical or vaginal fistulae, were all regarded as hopeless. This type of extension prevented resection in 43 instances in all of which the liver was free from palpable metastases. In 11 patients, the local lesion seemed suitable for radical operation but the liver was grossly involved with metastases, while in 15 instances the lesion was hopeless both because of local extension and because of metastases in the liver. Positive evidence of metastases in the inguinal lymph nodes precluded resection in one case while old age made resection impossible in five patients in whom the lesion was otherwise suitable. We feel that in none of these patients was a favorable chance for radical operative attack on the carcinoma missed.

The hospital mortality of these patients upon whom colostomy was performed was under these circumstances 22 per cent. Of these, more than one-half, or 12 per cent, of the group died within the first week, while the remainder lingered on to die after an average of 35 days, of some complication of the original disease. We have been interested in following this group of patients in an endeavor to see whether colostomy is worth while in the hopeless cases (Table III).

TABLE III

MORTALITY IN PATIENTS UPON WHOM PALLIATIVE COLOSTOMY WAS
PERFORMED

Total number palliative colostomies.....	85
Hospital deaths.....	18 = 22%
(A) Died within 14 days..... 10 (avg. 6 da.)	= 12%
(B) Lived over 14 days..... 8 (avg. 35 da.)	= 10%
Cause of death in Group A:	
Intestinal obstruction.....	4
Pneumonia.....	1
Peritonitis.....	1
Cardiac disease.....	1
Age, disease.....	3
Group B:	
Died of extensive cancer, general peritoneal, liver.	

If the patients were able to leave the hospital, they were found to live an average of ten months. Whether this is worth while it is difficult to say, but there is usually a marked lessening of pain, bleeding, and tenesmus, and about one-third of them gained weight and strength. The shortest duration of life was one month, while one patient, with proven carcinoma, is still alive after four years.

From this rather brief experience we feel strongly that in the patient unsuitable for radical operation, a colostomy is worth while and that the earlier in the course of the disease it is performed, the more beneficent are its results. There is a common feeling that this operation should only be carried out for obstructing lesions. This view is fallacious, as it gives as much comfort to those suffering from pain, tenesmus, and hemorrhage as it does to those with obstruction. Obstruction usually develops late, or never, and to wait for this complication to ensue is to deprive the patient of much comfort and to shorten his life. Colostomy performed in the terminal stages of the disease carries a high mortality, when its utility is questionable. In the majority of patients in whom for one reason or another one decides to employ roentgen therapy or radium, we have found it more comfortable and in general more satisfactory to carry out this treatment after a colostomy has been established.

Obviously no one type of operation should be used for all kinds and locations of carcinoma in any organ and we have endeavored to suit the treatment to the lesion. Seven patients with small, low lying lesions were operated upon by preliminary colostomy with a later perineal excision. Three of these patients were also regarded as poor risks for a more extensive operation. The single death in this group occurred suddenly ten days after the second stage, in a patient having a normal convalescence. Unfortunately, an autopsy was not permitted.

The abdominoperineal operation was carried out in two stages on 27 patients and in one stage on 72 patients. We feel that the greatest contribution to the success of this operation, no matter how it be carried out, is the principle of proper rehabilitation of the patient so strongly insisted upon

by Miles in England and Rankin² in this country. In the earlier part of this period, we employed a two stage procedure as a routine with results that were satisfactory to us. The operation commonly used was that of exploration through an inguinal incision and if found satisfactory for the radical operation, the sigmoid was cut across, the lower end being closed and dropped into the abdomen while the upper end was drawn out through the incision to form the permanent colostomy. Later, the lower end of the sigmoid and the rectum were removed at the second stage. It appeared that the second stage of this operation was as long and as difficult as the one stage operation and the mortality of the one stage procedure should not be higher because of operative trauma if the patient could be brought to operation in as good condition. Often the second stage of the two stage operation was technically more difficult than an original attack would have been, since adhesions were frequently found that hindered a smooth dissection. It was then decided to attempt the one stage operation after the method of Miles upon a series of patients, on the assumption that it would be an easier operation to perform, it might shorten the patient's hospitalization and, at least, we would learn of its limitations.

The methods of preparation of the patient developed by other workers in this field have been employed. Usually from five to ten days are needed for this process and the average time spent in the hospital in this group was seven days. The bowel is emptied by the use of weak saline purges given frequently, with daily enemata. Most patients with mild symptoms of obstruction can be decompressed satisfactorily by this regimen. Cecostomy was necessary in only three patients, all others being handled by nonoperative measures. It is probable that we have erred on the side of not giving enough time to the preparation and in the future we purpose to take a few days longer for this important step. The patient should spend most of the time in bed, eating a low residue, high caloric diet with high fluid intake. Associated defects are corrected and transfusions are given in case anemia exists.

In all of the patients upon whom the one stage operation has been performed the peritoneum has been protected against infection by the introduction of bactrogen as developed by Steinberg.³ If the operation is performed in two stages, the preliminary colostomy has the same effect of raising the local immunity of the peritoneum to infection and therefore the introduction of any substance for this purpose is unnecessary. This substance is composed of 5 per cent aleuronat, 600 million *B. coli*, killed by formaldehyde, and 30 cc. of 1.5 per cent solution of gum tragacanth. In the early cases this was introduced into the peritoneal cavity 48 hours before operation but this time has been shortened until it was given 12 hours before operation. Steinberg has recently found that the desired reaction can be secured in three hours and we now introduce the bactrogen at the close of the operation. The effect produced is not specific but is entirely an hyperleukocytosis. The leukocytes will attack any bacteria that are capable of being destroyed by phagocytosis. The important point is to produce a sufficiently large number of phagocytes, in a short period of time, to destroy

bacteria present before toxins can be developed. The action of the bactrogen is limited in time and after three days the protective reaction rapidly disappears. It can be reintroduced at this time if it is desired to maintain an hyperleukocytosis as a barrier against infection. We feel that the use of this substance is worth while to guard against contamination that occurs not infrequently in the operations we have performed. In dissecting the rectum, in those cases in which the carcinoma has infiltrated the entire thickness of the bowel, it is almost inevitable, at times, that the bowel may rupture with resultant contamination of the field. This has occurred 11 times in this series, and while the wound in the abdominal wall and the perineal wound have been infected, the peritoneum has apparently taken care of itself in every instance. Sepsis may later spread from the infected posterior wound but in no instance have we seen acute peritonitis of the usual type follow even gross contamination when the bactrogen was used. It would seem that this protection of the peritoneum is worth while in the one stage procedure as at least giving the same immunity to infection that it has in the two stage operation as a result of the carrying out of the preliminary colostomy. We have used the intraperitoneal injection of some form of bactrogen about 300 times and no harmful effects have been noted. There is usually a fever that averages 101° F. and a general leukocytosis that averages 17,000. There is some abdominal discomfort that is readily controlled by an opiate.

The anesthetic employed has uniformly been spinal, supplemented if necessary with very light nitrous oxide and oxygen. It has been found that a comparatively small amount of drug is adequate and the usual dose is 80 mg. of novocaine to which in the past year we have added 20 mg. of pantocaine. The effect of spinal anesthesia on the bowel makes the abdominal part of the operation very much easier and is almost a necessity.

The operation is carried out as closely as possible following the principles of Miles. With the patient in the Trendelenburg position a three inch incision is made through the inner third of the left rectus muscle and exploration carried out. If the lesion is not suitable for radical removal a colostomy is performed through this incision. If the radical operation is feasible the incision is enlarged to provide a good exposure and the operation carried out as described by Miles. The upper end of the pelvic colon is either drawn out through a stab wound in the left inguinal region or allowed to project from the original incision. No sutures are placed in the bowel which is allowed to remain without tension where it will. It is desirable to leave as much bowel out as can be readily secured, since it is impossible to predict exactly where the blood supply will be and a long segment of exteriorized bowel will enable one to guard the wound against contamination with some certainty. As soon as the wound has healed, the protruding bowel is cut across about two inches from the skin surface to form the permanent colostomy. The patient is then placed in the Sims position and the rectum dissected out with the fat from the ischio-rectal fossae. The prone position with hips flexed was used on many of the patients as it gives

a much better exposure for the surgeon but it was noticed that there was frequently a fall in blood pressure with this change of position and consequently it has been given up for the lateral position, which gives a satisfactory exposure, and in which no changes of blood pressure have been noted. The posterior wound is closed at both ends leaving the middle wide open for the introduction of a large sheet of rubber dam which is passed well up to the pelvic diaphragm. This is removed in three or four days and replaced by smaller drains of the same material.

Following the operation a transfusion is given if the patient shows any signs of shock or if he fails to react in a perfectly satisfactory manner. Transfusion has been carried out in about one-half of the patients in this group.

The postoperative care of these patients has no special features except the handling of the colostomy. One of the outstanding advantages of the two stage operation is that the colostomy is established and working while in the one stage procedure the difficulties of regulating the colostomy are superimposed upon a patient recovering from a severe operation. We have not had any great difficulty with the colostomy since we have regarded it as a true intestinal obstruction. The exteriorized loop is left closed as long as possible without allowing abdominal distention to occur. A catheter may then be introduced which often will care for the obstruction for several days longer. Eventually the loop is completely opened. We have discontinued the use of irrigations or any other source of irritation of the colon. If reverse peristalsis occurs with nausea, vomiting or distention, constant suction of the stomach, after the method of Wangensteen, is employed. This procedure is used intermittently until the tone of the intestinal musculature is restored and normal peristalsis is reestablished.

The patients are kept in bed for two weeks and then allowed up for increasing periods of time. They are urged to walk as soon as they are able as it seems true that the posterior wound fills up much faster if the patients are up and about. The average time of hospitalization after operation is 27 days. The posterior wounds are healed in about three months.

RESULTS.—The hospital mortality in all patients upon whom an attempt was made to cure by operative measures is shown in Table IV, but these figures taken alone do not make a true commentary on the actual facts.

TABLE IV
CASES UPON WHOM CURATIVE OPERATIONS WERE ATTEMPTED

	No.	Mortality	Per Cent Mortality
Colostomy—did not return for second stage.	4		
Colostomy with perineal excision.	7	1	14
Two stage abdominoperineal operation.	27	7	26
One stage abdominoperineal operation.	72	12	16.5
Total.	110		

The mortality for the two stage operation is 26 per cent but this is unfair to this procedure. Twenty-three patients considered as good subjects for radical operation were operated upon by this method with a loss of three patients as shown in Table V, a mortality of 13 per cent.

TABLE V

PATIENTS DYING FOLLOWING MULTIPLE STAGE ABDOMINOPERINEAL OPERATION

	Age	Sex	Time	Cause	Remarks
(1)	64	F	45 days	Sepsis. Perineal with fecal fistula in perineum	Favorable lesion
(2)	45	F	11 days	Peritonitis. Wound sepsis. Hepatic metastases	Local lesion favorable
(3)	69	F	2 days	Peritonitis. Pneumonia. Wound sepsis	Hypertension. Lesion favorable
(4)	55	F	1 day	Shock	Advanced lesion infiltrating vagina, supravaginal hysterectomy also done at time of operation
(5)	48	M	1 day	Cardiac collapse	Extensive lesion. Could not be removed completely
(6)	64	F	8 days	Auricular fibrillation. Cardiac failure	Hypertension $\frac{3}{4}$ annular. Nodes +
(7)	63	M	8 days	Auricular fibrillation. Cardiac failure. Anuria	Favorable local lesion

Within the past year four patients were operated upon in stages because they were recognized as desperate risks and it was hoped that after a colostomy and a rest period of several weeks, they might be generally improved to a point where a cure might be attempted. Two of them were elderly people with marked hypertension and cardiovascular disease and the other two were patients with far advanced lesions fixed in the pelvis. Eventually a radical resection was attempted with fatal results in all four patients. Consequently the mortality is not that of the operation but was due to the poor judgment that attempted operation on patients that were inoperable.

As shown in Table IV, the hospital mortality for the one stage procedure was 16.5 per cent, which requires some explanation. In the first 48 patients upon whom this operation was performed, there was a mortality of 8.3 per cent. These patients were carefully selected both from the standpoint of the lesion and their general condition. During the past year we have striven to increase the operability of our patients with carcinoma of the rectum, which meant that we have operated upon patients who are not good risks because of advanced age or other general conditions and we have attempted operation upon lesions that have been found to be locally hopeless when operation was finally attempted. The four patients already mentioned as dying after the two stage operation fall into this group. In Table VI is shown a more detailed analysis of the patients dying after the one stage

CARCINOMA OF THE RECTUM

procedure. The first four patients were old, and poor risks on that account. All of them lingered on for from nine to 17 days, dying of pneumonia or cardiovascular disease. Only one patient in the group over 70 survived the operation and it is questionable whether one should attempt the operation in anyone past 65.

TABLE VI

PATIENTS DYING FOLLOWING ONE STAGE ABDOMINOPERINEAL OPERATION

Patient	Age	Cause of Death	Time	Remarks
(1) B. F.	74	Pneumonia	9 days	Advanced lesion invading pelvic fascia
(2) N. H.	71	Auricular fibrillation. Uremia	17 days	Obesity. Local lesion favorable. Nodes +
(3) G. M.	72	Auricular flutter	17 days	Local lesion favorable
(4) A. S.	66	Bronchopneumonia	14 days	Local lesion favorable. Advanced arteriosclerosis
(5) C. D.	55	Pneumonia	2 days	Advanced lesion invading pelvic fascia. Hypertension. Chronic nephritis. Liver metastases at autopsy. Nodes +
(6) M. W.	36	Obstruction. Infection in posterior wound	14 days	Far advanced lesion infiltrating. Nodes +
(7) W. O.	65	Sudden death. ? vascular accident	2 days	Advanced infiltrating lesion. Nodes +. Obesity
(8) H. L.	60	Gangrene colostomy loop. Reoperation	6 days	Advanced infiltrating lesion. Nodes +
(9) B. T.	58	Posterior wound sepsis. Secondary hemorrhage	9 days	Favorable lesion
(10) E. S.	43	Pneumonia-embolic. Septicopyemia. Posterior wound sepsis	24 days	Local lesion favorable
(11) P. B.	52	Posterior wound sepsis. Urinary tract infection. Peritonitis	35 days	Lesion favorable. Nodes +. Obesity
(12) W. L.	65	Bronchopneumonia	2 days	Favorable lesion. Moderate arteriosclerosis

The next four patients all had lesions that had passed through the bowel wall and invaded surrounding structures and viscera. In short, they had lesions incurable by operation and operation should not have been attempted. The operative mortality is high in these patients as anatomic planes are lost, operative trauma is greater, and infection, by breaking through the bowel, is common. The first eight patients in the mortality list were all badly selected as only two of them had lesions that might have been cured by operation and these two patients were poor operative risks because of advanced age.

There were two deaths from postoperative accidents, one from hemorrhage from the posterior wound on the ninth day and another from sloughing of the exteriorized bowel. Three other patients died of infection, two from extension of infection from the posterior wound and one from pneumonia. Of all these patients only six had lesions favorable for operation. The mortality for the one stage operation is then somewhat, if not largely, dependent upon the selection of patients for the operation.

In our endeavor to increase the operability of patients with this disease we have certainly operated upon patients who should not have been treated in this manner. While we have attempted curative operations in 49 per cent of the patients, the true operability was probably not greater than 35 per cent. The mortality has risen as we have increased the percentage of those operated upon. One should be critical of high operative mortality but in this instance not too critical, as we are dealing with patients with hopeless lesions that will in a short time cause death anyway, and if, by an aggressive attitude of mind, one can cure an occasional borderline case, it may be worth while. We have determined, however, to return to a somewhat more conservative selection of patients for the radical operation. Every patient over 65 should be considered most carefully before advising operation. Patients with marked hypertension and cardiovascular disease should probably all be treated conservatively. The matter of local extension of the lesion to pelvic structures, as shown by fixation, is often hard to determine, but clearly we have tried to resect a number that were not resectable and our judgment here has most often been at fault. With a better selection of patients, the mortality of the radical operation will be lower. From this rather limited experience, we feel that the one stage procedure has a distinct place in the treatment of carcinoma of the rectum and rectosigmoid. If obstruction is not present and if plenty of time is taken to prepare the patient for operation, we feel that the mortality from the operation should be not greater than that of the two stage operation. The greatest mortality, with us, has been due to a deliberate attempt to increase the operability of the disease and is not due to the use of any particular type of operation. With a proper selection of patients, the mortality should be 10 per cent or less.

CONCLUSIONS

The most important point in the operative treatment of carcinoma of the rectum is the recognition of the importance of the radical method of abdominoperineal resection as advocated by Miles.

Whether this is accomplished in one or in several stages is a matter of personal preference of the surgeon and of distinctly less importance. Most patients can be operated upon as safely by the one stage as with multiple stage operations if proper preparation of the patient is effected.

Higher operability will come with earlier diagnosis and not from attempting the operation upon far advanced lesions or on the poor risk patient.

Bactrogen (Steinberg) has a place in protecting against infection if gross contamination occurs.

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DISCUSSION OF THE PAPERS OF DOCTORS RANKIN AND COLLIER

DISCUSSION.—DR. DANIEL FISKE JONES (Boston, Mass.).—I believe that a two stage operation, or the posterior operation of Mummery, should be the operation elected by those of little experience. And I think that if one pays attention to these cases he will find that the number of one stage operations will increase quite steadily. I have been accused of performing the two stage operation always; as a matter of fact I have performed just three two stage operations in the last two years, which I think corresponds very well with what Doctor Rankin has said.

It seems to me to be our duty to operate upon these patients when possible, and one cannot operate upon all of them by a one stage procedure. I cannot understand Dr. T. E. Jones' attitude toward the two stage operation. In the most recent article of his, that I have seen, he states that if you perform a two stage operation there are mortality risks incident to both stages, and that the mortality in those two stages will probably be equal to, if not greater than, the mortality in a one stage operation. That depends upon what you have been doing and what you want to do. I know that there are some patients upon whom I have operated with a two stage operation or with a posterior operation, who could not possibly have been operated upon with a one stage operation. It is, I believe, much better to perform a two stage operation, either a combined abdominoperineal amputation in two stages or a colostomy and posterior excision, than to do nothing at all. I therefore do not see that Doctor Jones has any argument at all, and I do not know why he should just throw out the two stage operation.

I have never in any of my articles, that I know of, stated that you must do a two stage operation or that you must do a one stage operation. The man who is doing this work must have some judgment as to what to do, and I would advise the surgeon beginning with this operation to begin with a Mummery operation, namely, a colostomy and posterior excision, or a two stage combined abdominoperineal operation, and then go on to the one stage operation as he feels that he has the ability to do it. If he does that, he will save a good many lives.

As to vaccination, I have not used vaccination for one particular reason, and that is that if you have a colostomy which you want to close or a colostomy following a Mikulicz operation, there is no use attempting to close it inside of eight weeks, and the nearer you are to the time of the first operation, the surer you are to have infection. It seems to me, therefore, to be a rather useless procedure to use the vaccines and then go to work and operate within a week. It takes at least six weeks for a patient to be-

come immunized after a colostomy; it would seem reasonable, then, to assume that it would take more than 24 hours or a week to immunize a patient with vaccines.

As to the resection of the presacral nerve, I wish that Doctor Rankin would find a method of improving the bladder function afterwards. Mr. Miles nearly floored me when he told me that he had never had a cystitis following an operation for carcinoma of the rectum. I have never had anything but temporary paralysis and cystitis. I began, and have continued up until just recently, with the removal of the presacral nerve. Now I am not resecting it, but I cannot see that it makes an iota of difference. If Doctor Rankin can, I shall try it again. I do get infection of the bladder and I do not see how you are going to avoid it as a resultant of the temporary paralysis.

As to the mortality rate, there is no use talking about the mortality rate in these cases unless you give the percentage of operability. Doctor Rankin has just said that his operability was 76 per cent. He must have a large number of good general practitioners down around Lexington, because I have never been able to approach 76 per cent. I have been up to 67 per cent, but that included the posterior operation and the two stage operation.

One thing that I should like to do is to urge every man here to remove the growth when possible, whether there is a nodule in the liver or not. The condition of these patients following removal of the growth and a colostomy cannot be compared in any way with the physical discomforts, displeasures and the mental effect which follow a simple colostomy. I think that if any one of you had a cancer of the rectum and somebody told you that he had performed a colostomy for you, you would not get very much pleasure out of that operation if you knew that the growth had not been removed. On the other hand, if a surgeon can go to a patient and say, "Yes, I have made a colostomy as I said I would, but I have removed the growth," the patient will have a good time so long as he is comfortable. And I believe that in these cases that is worth while.

As to the interest in these cases, I am pleased that there is very little talk now about not being able to perform the operation because the patient would have to have a colostomy. That attitude, thank goodness, has largely disappeared.

Doctor Rankin read a paper at the Southern Medical Association meeting and told them that they should perform colostomies even as palliative operations, and there was not a murmur against it. The last time I urged colostomies in all cases of carcinoma of the rectum, I was set upon by several older gentlemen who told me that they had operated upon cases who were alive and well after 14 or more years. I asked, "What operation did you do?" They replied, "Just a local operation." That was to show me that the colostomy was quite unnecessary. It really is a great pleasure to see the change in the attitude of the doctors around this country in regard to a colostomy.

If I may say something about a colostomy, I should like to state that there is no such thing as control of the colostomy by any operation that I know of, and I should be very pleased to know if anybody here has ever heard of a type of colostomy that would control the bowel movements, because I should like to try it. I have never seen one yet. You can control the evacuations, however, by teaching the patient what and how to eat and how to take care of his bowels. I have very, very few patients who ever have any trouble with their colostomies after being taught how to care for

them. If they try to care for their colostomies themselves without instructions, they always make a mess of it.

If it would be of any comfort to some of you gentlemen, I should like to say that while Doctor Collier keeps his colostomies closed as long as he can, I think that he will get along with perfectly clean wounds in 99 per cent of his cases if the bowel is brought out of the original abdominal wound and if the colostomy is opened within 24 hours. I think that if you open up your colostomy early, you are not liable to have your patient nearly so distended and uncomfortable, and the wound will not become infected.

DR. FRANK H. LAHEY (Boston, Mass.).—I think that carcinoma of the rectum is such a hopeful lesion, when all of us can report five year non-recurrences ranging, we will say, from 35 to 45 per cent, that this subject demands a great deal of interest. It demands that all of us interest ourselves in the various measures which will increase operability, lower mortality and increase curability.

As to the two stage and one stage procedure, it seems to me that all of us owe a great deal to Doctors Mummery, Jones, Rankin, Lawrence Abel, Thomas Jones, and others who are employing these different types of procedures. But we come back to one thing that I would urge as the result of our experience, and that is that you can only learn by experience with these cases, and that the two stage procedure in the hands of the men who have not had a large experience is certainly safer than a widening of the range of one stage operations before you have had a large experience. It is like preliminary ligations of the thyroid that we spoke of yesterday and two stage thyroidectomy. You cannot write such descriptions down; you cannot vividly describe such cases and indications. If you could, you could take a correspondence course in when to do the two stage operation and when to do the one stage procedure. I think that there is nothing which has been more strikingly demonstrated to us than the need for experience before forsaking two stage procedures. None of us desire, particularly, to discuss types of operation. We all do our own operation better than the other fellow's; we all select the type of operation that fits us and fits our cases.

I think there are one or two things that are of interest. Our operability is the same as Doctor Rankin's and I think it can be kept that high. It certainly has definitely increased. Up to 1934 it was 53 per cent, and it has been raised to 73 per cent during the last two years. Our mortality, when operability was 53 per cent, was 8.25 per cent, and now it is about 12 per cent.

I agree with Doctor Jones. I do not think we ought to be too much interested in mortality, because, as Doctor Rankin has said, when you get interested in mortality down comes the operability, and down comes the curability. I agree also very definitely with Doctor Jones that the primary consideration is to make these patients live the longest time comfortably and that is the reason we have increased our operability.

There are one or two other points which I think are of interest and value to anyone who is dealing with cancer of the rectum; one is to aggressively oppose the patient and the general practitioner who want to limit the operative procedure because the lesion is small. So many times these patients are sent to us by their doctors with a small lesion the size of my little fingernail and they want a local resection. If ever there is a chance in the world to accomplish cure, and if ever there should be a time when aggressive surgery should be undertaken, it is then. There are so many sad experiences. A few years ago a young man with a papilloma just within the anus came to

us, rejected radical operation and had local application of radium elsewhere, only to return in a year with a recurrence, have us do a two stage operation and die of the recurrence. That boy certainly should have had a radical operation in the beginning and if he had would probably be alive today. I think it is our duty to advocate radical surgery in the presence of small lesions.

I think we owe Doctor Jones a great deal for stressing colostomy. The patient judges the end-results in terms of his colostomy. He forgets within a year that he has been cured or relieved of a carcinoma and thinks only in terms of how well he gets on with his colostomy.

There are certain things concerning colostomy which from our experience are also of value. If you want to have good results from colostomies, make the patients come back frequently, see them frequently, listen to their problems and teach them how to constipate themselves. There is something about a colostomy that takes time for adjustment. Warn the patient that for six months he will have a little trouble about managing his colostomy, and at the end of that time he will begin to know how to manage it, and he and it will function better. Place, as we have, in various parts of the community people who are grateful for relief and who manage their colostomies well. They will go out and help convince individuals who reject radical operations by demonstrating that their colostomies do work well. I believe this is an extremely hopeful lesion, that we should all approach it aggressively and enthusiastically and that with this approach we can widen the operability, decrease the mortality and increase the curability.

DR. MONT ROGERS REID (Cincinnati, Ohio).—I want to bring up one point which was not touched upon by either Doctor Rankin or Doctor Collier. A few years ago I advocated the judicious use of lead and opium pre- and postoperatively, when dealing with carcinoma of the large bowel. This has proved of the greatest assistance. After the patient has been properly prepared and the intestines cleared out as well as possible, the lead and opium are given a day or two before the operation, and then postoperatively as long as one wishes to prevent any bowel movements. Under this regimen one can make the colostomy opening at any time and get absolutely no fecal drainage. It does, however, allow the escape of gas. In addition its use has another distinct advantage, in putting the intestines at rest, which materially aids in wound healing. I never resect intestines without the use of lead and opium both before and after operation.

DR. J. SHELTON HORSLEY (Richmond, Va.).—There are two points that I should like to discuss briefly. One is concerning the vaccine, or more properly, the coli-bactrugen of Steinberg, that Doctor Collier referred to. I have been using it for some time. My conclusions have been somewhat different from his. I noticed that several times there was a very severe reaction. On one or two occasions I have been forced to postpone the radical operation because of the illness of the patient. Steinberg says that the height of immunity is about 48 hours, but these patients are too ill, and invariably when I have postponed it for, say, six or seven days, contrary to experimental results, the results have been rather happy, and almost always when I have operated in the first 48 hours the results have not been so good.

In regard to the resection of the rectosigmoid or the upper rectum. I have employed a procedure that was apparently quite satisfactory, so far as immediate results are concerned. In the upper rectum and the terminal sigmoid, it is the custom, I believe, to make a permanent colostomy. If, however, the patient is prepared by a competent cecostomy on the right side,

through a muscle-splitting incision, in which the bowel is brought up and a glass rod is put through the ascending mesocolon, so that the distal bowel can be put at complete rest and irrigated with salt solution either through the colostomy or the rectum once or twice a day, and the coli-bactrugen is given, an end-to-end union can be effected. The patient is placed in the extreme Trendelenburg position. The operation is performed as if the entire rectum were to be extirpated, and the tissues in the hollow of the sacrum are freed as in the complete radical operation. The upper stump is then brought down after it is cleaned by placing two long tractor sutures of linen, after rotating the upper stump outward so that its posterior surface will be covered with peritoneum. These very long sutures are gradually tightened as the upper stump is shoved down into the pelvis. The tractor sutures are then tied, and the posterior margin of the upper stump is sutured to the posterior margin of the lower stump, making it quite snug. This suture is carried along in front, inverting the margins as much as possible. This row of sutures is reinforced by a series of interrupted mattress sutures of fine chromic catgut which are then passed through adjacent fat.

Two weeks later, the enterostomy is closed. Enemas should never be given after the resection. I am confident I killed a patient by administering one two weeks after a resection, when he was doing pretty well.

That procedure, I believe, will, in that type of case, substitute an end-to-end union for a permanent artificial anus, and effect a sufficiently radical operation.

DR. HARVEY B. STONE (Baltimore, Md.).—I think both of the essayists are to be congratulated for their courage and honesty. Of particular interest is the statement by Doctor Rankin that he has come to the conclusion that the vaccine which he did so much to develop, and in which he was so hopeful of benefit, has, in his judgment, no longer sufficient justification to be continued, and the frank admission by Doctor Collier that the effort he made to extend the operability in his series of cases seems unwarranted and that he is going to reverse his position.

I should like to say, too, that I agree with all six of the modifications that Doctor Rankin has made lately in his technic in the handling of these cases. They coincide very closely with our practice in Baltimore, and we have felt that they are all helpful.

There is one phase of the subject which I would like to call attention to: A question of certain types of inoperable carcinoma of the rectum or rectosigmoid, where operative attack as the best form of palliation, as advocated by Doctor Jones, seems too extensive a procedure to be justified; where, for instance, the bladder, or other adjacent structures, are involved, and the palliative removal of a hopeless carcinoma is too formidable an operation to be worth attempting, and yet the patient is not actually obstructed.

There is a procedure which has given us a good deal of help at times, and that is the performance of a so called precolostomy. In such cases, after the exploration has determined that it is inadvisable to make an attempt at removal of the growth, and at the same time the patient is not seriously involved in difficulties of an obstructive nature, we draw up the sigmoid into a small lateral wound and fix it there without opening it, fixing it in such a way that only a small portion of its circumference is attached to the skin.

That forms a potential colostomy, which may be opened as desired at any later period. In a good many such cases patients may not die for a year or more subsequent to the exploratory operation, without ever requir-

ing the colostomy to be opened. On the other hand, some cases following the handling of the exploratory procedure, within a few days after the first operation, develop complete obstructive conditions, and at once, without further difficulty, the knife can be plunged into the attached loop of bowel and the colostomy completed.

DR. FREDERICK A. COLLIER (Ann Arbor, Michigan).—I have just one comment to make, and that is, that I still think the hyperleukocytosis that is produced by Steinberg's bactrogen is worth while in many instances. It is not a vaccination in any way, but simply produces an irritation with a marked local leukocytosis, and I may say, for Doctor Horsley's benefit, that it has been changed tremendously within the past year. The action is now obtained in three hours, and the reaction (we have used this form on 50 or 60 cases) is minimal. If contamination does take place, as it will not infrequently, one has in this, I think, a substance that is of distinct benefit.

I have tried to bring out the fact that, in the patients that we treated in this group which has been analyzed, we have positive proof by autopsy or direct observation that 68 and perhaps 70 per cent of them were hopeless. and that the lesion had passed beyond the reach of any surgeon. Higher operability will come with early diagnosis. The patients coming to our clinic now come, in most instances, because they are incapacitated, consequently our operability is low. We have tried to increase the operability by attempting to cure hopeless cases. We have learned our lesson and will try in the future to increase the percentage of operability by teaching earlier diagnosis.

IMPERFORATE ANUS WITH RECTOVAGINAL CLOACA

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THE various anomalies in the development of the rectum and anus are well known to the student of embryology and of interest to the surgeon. In some of them complete obstruction of the bowel exists and requires prompt intervention to save the infant's life. In others the rectum is not completely blind, but instead of opening through the anus normally, the anus is absent and the rectum opens into some other hollow viscus. This paper concerns itself particularly with those cases in the female in which the rectum opens into the vagina. These organs normally communicate or form a common cloaca during one period of embryonic development, but later the hindgut becomes separated from the urogenital sinus by the development of a septum between these two passages, and the former, the hindgut, opens to the surface by its fusion with the proctodeum that dips inward from the perineum, thus leading to the formation of the normal anus. Sometimes both these processes, that is, the separation of rectum from vagina and the opening of proctodeum into rectum, fail to occur and the incomplete embryonic state persists. This leads to a condition of imperforate anus and rectovaginal fistula or cloaca.

The occurrence of such an anomaly has been long known. Bodenhamer,¹ in his interesting monograph entirely devoted to congenital anomalies of the rectum and anus, cites references dating back to classic antiquity and mentions records of similar lesions in the dog and cow. He states, however, that this is a rare condition, and cites all of the few instances to which he could find reference. Since his time there have, of course, been other cases reported, but one is struck by the scantiness of discussion of the subject in any of the works consulted. Many of the text-books on surgery omit mention of it or barely state that such an abnormality exists. Even with volumes devoted to the rectum and anus the subject is dealt with, if at all, in very cursory fashion. This is, of course, entirely proper. The rarity of the condition does not justify extensive discussion in general treatises. Furthermore, as several authorities point out, this particular form of imperforate anus is apt to be less serious than most of the other varieties because the rectal orifice into the posterior vaginal wall is usually of sufficient size to permit adequate emptying of the bowel, or if it is not large enough it may be easily found and readily enlarged by stretching or incision. Hence, life-threatening obstruction is rare. It does occur, however, when the communication is very small and high in the vaginal vault. Such cases may require colostomy to save the child's life, and are apt to be associated with double uterus. The writer has seen one such case. Much more commonly the rectum opens into

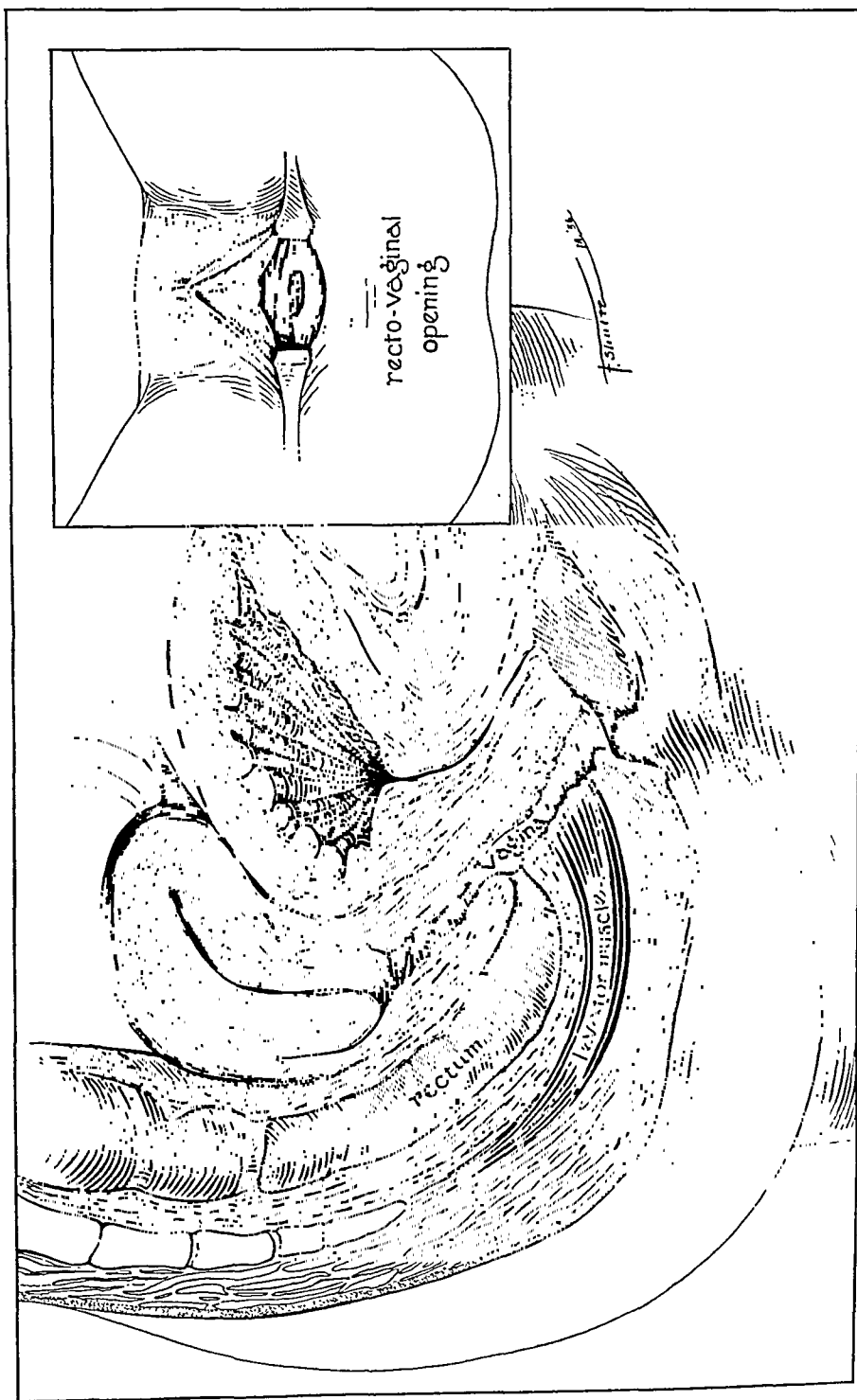


FIG. 1.—Sagittal section of imperforate anus and rectovaginal cloaca. Insert shows opening of rectum into vagina.

the posterior vaginal wall lower down, and indeed it has been said that the commonest location of the opening is in the fourchette.

So far as symptoms are concerned they are the obvious result of the abnormal location of the rectal orifice. Absence of the anus or a rudimentary dimple-like depression is the external evidence of the condition, combined with escape of meconium or stool from the vaginal outlet. There is usually an accompanying incontinence although sometimes there seems to be a partially effective sphincter-like power in the tissues about the rectovaginal opening. In social groups that are careless or unobservant, it is said that the condition may even escape detection and there are reports of women who had reached adult life, and had even borne children, without themselves being aware of their abnormal condition. As a rule, however, these patients suffer the disagreeable results of fecal incontinence and not infrequently the partial obstruction that goes with an inadequate rectal orifice. They have soiling, skin irritation, constipation, straining, and may develop one form of giant colon. Such a state of affairs clearly calls for efforts at cure or improvement.

So far as the writer has been able to discover, in a fairly extensive, but by no means exhaustive, search of the literature, there is only one form of operation described and utilized for the treatment of these lesions—that of Rizzoli.² In this procedure, an incision is made backward in the midline through the posterior vaginal wall, the fourchette, perineum and skin, from the edge of the rectovaginal fistula to the position that the anus would normally occupy. The rectum is detached from the vagina and drawn backward through the cleft perineum to its new position where it is sutured to the skin. The divided perineum and posterior vaginal wall are then sutured together in front of it, in order to reconstruct the normal relations. The results of this type of operation are generally described as good, but in some cases the repaired perineum has not held well and control has been unsatisfactory.

The writer offers a somewhat different technical attack with the same objectives—closure of the fistula into the vagina, restoration of the anus to its proper location and restoration of sphincteric control.

OPERATIVE TECHNIC.—With retractors in the vaginal outlet to expose the rectovaginal fistula, a circular incision is made about this opening, separating the rectal and vaginal mucous membranes from each other. This incision is deepened about the rectal wall and the dissection is carried upward about the rectum on all sides until it is freely mobilized. As the anterior rectal and posterior vaginal walls often are in very close contact, meticulous care in dissection is sometimes needed to avoid making a hole in either viscus. The mobilization should be carried as high as possible without opening the peritoneum of the cul-de-sac of Douglas, which is to be avoided if possible. After this dissection is completed, the rectum lies free and separated in the space between the vagina in front and the sacrum behind, while below it the levator ani muscle forms a continuous layer across the perineal floor. The next step is to make a small oval removal of skin in the position where the anus should be. Sometimes this will be indicated by a dimple, or the sphincter

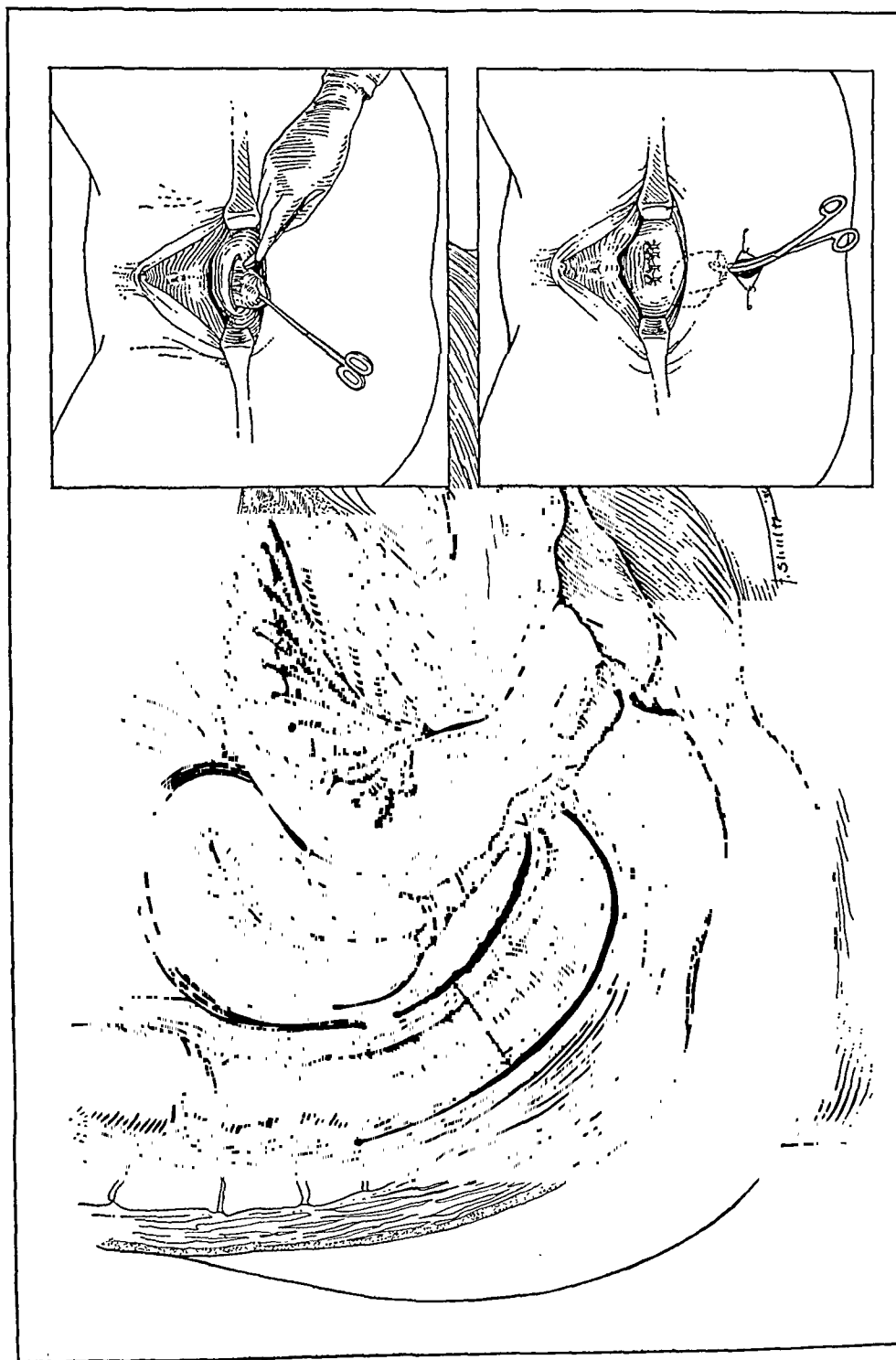


FIG. 2.—Mobilization of rectum by dissection from surrounding structures. Upper insert shows beginning of dissection by separation of rectovaginal orifice. Lower insert shows drawing of mobilized rectum downward through normal anal location. The vaginal opening is shown here closed by stitches.

may be palpable under the skin. Often neither of these aids is present and the operator selects the anal location without special guidance. Through the skin wound that is to form the new anus a closed straight hemostat is thrust and worked, by blunt dissection, upward through the fascia and muscle of the levator until it penetrates into the free dissected space about the rectum. The passage through which the hemostat has made its way is stretched and enlarged carefully, without division of muscle fibers, until the index finger can be passed through it. Through this passage a clamp is then introduced upward from the perineum, until one can grasp the free end of the mobilized rectum, which is drawn downward and outward to the skin surface of the new anus. To do this properly without strain or tension, the rectum must first have been thoroughly mobilized high up, and the opening through the levator stretched enough to allow the gut to pass without difficulty. The rectum is now anchored in its new position with four quadrant submucous-subcutaneous sutures of catgut, and the free end of the gut sutured to the skin of the perineum with interrupted sutures of fine silk. By this procedure the perineal body and such muscle as exists in the pelvic floor have been preserved intact. The levator closes snugly around the rectum that has been pulled through it, and while the hole in the posterior vaginal wall is still open, a few catgut sutures may be taken in the levator and fascial structures in front of the rectum in its new position, to further build up a perineal body and rectovaginal septum. Lastly, the hole in the posterior vaginal wall is closed.

This method of operative treatment has been employed in the three cases reported herewith. It has yielded uniformly good results. The vaginal closure has been firm, without a leak. The perineal body is substantial. The rectum opens in its normal position. The grasp of the levator on the rectum as it surrounds it has afforded excellent control for both gas and feces. A few comments may be made on certain points affecting the ease and success of the operation. It is best postponed until the age of puberty is approached, as the structures then are larger and much more satisfactorily handled than in very young infants. As was previously mentioned, this is possible as there is usually sufficient egress of bowel content to avoid obstructive symptoms in this particular form of anomaly, although sometimes a colostomy may be necessary. When the selected age is reached, a few days' preliminary treatment in the hospital before operation, to empty the bowel completely, is very desirable. After operation, defecation is avoided if possible for seven to ten days, to permit the wound to solidify before subjecting it to the passage of feces. The daily administration of mild opiates effects this. After defecation has begun, warm sitz baths, twice daily, aid in the cleansing, healing and comfort of the wound. Before final dismissal, several digital examinations and gentle dilatations of the new anus and rectum should be carried out, but not earlier than the 14th day, in order that the newly healing wounds may not be damaged. A late survey of the cases, some months after opera-

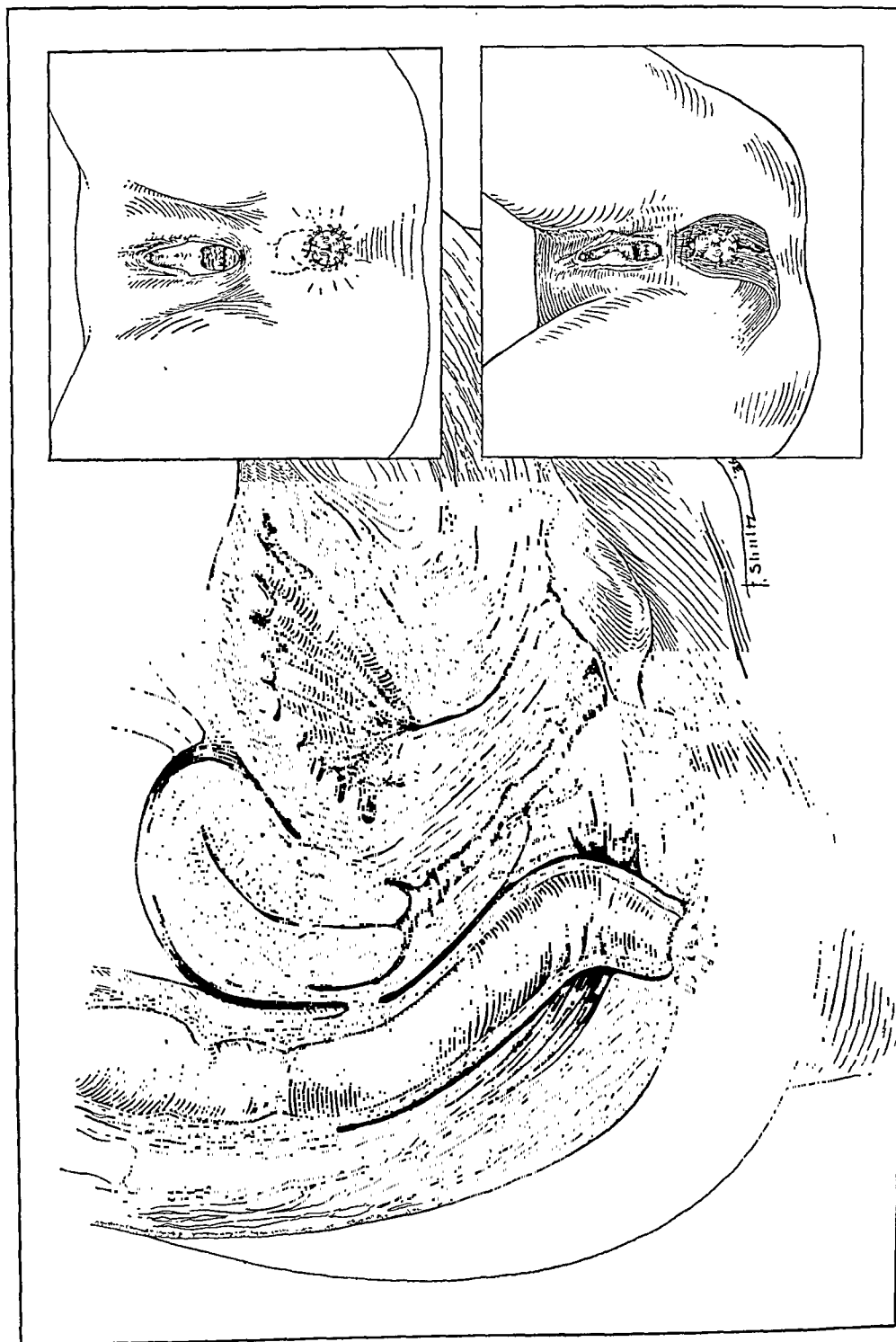


FIG. 3.—Sagittal diagram of completed operation. Upper insert shows view of same from perineum. Lower insert is attempt to indicate relation of levator muscle to new position of rectum.

tion, to determine the result, and to correct any tendency to stenosis, is desirable.

CASE REPORTS

Case 1.—No. 32812, Union Memorial Hospital. L. B., white girl, aged 13. Examination shows imperforate anus with a small scar, said to be due to an attempt to open the bowel by operation shortly after birth. When this failed, a colostomy was effected in the sigmoid, which is still open and functioning. In the posterior vaginal wall, one and one-half inches above the hymen, is a small opening marking the abnormal rectal orifice. The child is otherwise well developed, rather large for her age, and quite normal physically and mentally. The operation was performed as described June 27, 1934. On July 10, 1934, a digital dilatation was done. Convalescence was uneventful except for an intercurrent attack of pyelitis, and the patient was discharged after three weeks. She returned to the hospital one year later for closure of the colostomy, which was effected June 26, 1935, successfully and without incident. Examination at this time showed an excellent result. Normal appearing anus, good perineum, and excellent control of bowels without soiling.

Case 2.—No. 33117, Union Memorial Hospital. G. J. B., white girl, aged 13. Examination showed a small dimple where the anus should have been. The rectum opened into the posterior vaginal wall one inch above the hymen by an orifice, which had always been large enough to permit of easy defecation since birth. The child was otherwise normal, mentally and physically, well developed, and free from complaints, except for incontinence and irritation and excoriation about the vulva. The operation described was performed July 25, 1934. Wounds healed well, convalescence was uneventful, and the patient was discharged in three weeks. Examination some months later showed practically complete restitution of rectum, anus, perineum and vagina to normal with complete rectal continence.

Case 3.—No. 66891, Johns Hopkins Hospital. M. C., white girl, aged 10. Child was born with imperforate anus, the rectum opening through the posterior vaginal wall, low down. There were several other anomalies—an extra thumb on each hand, which was removed in early infancy without impairing the usefulness of hands, absence of coccyx, unilateral asymmetry of sacrum, fusion of several vertebrae, *etc.* For the past year or two, the child has had curious monthly attacks of mental disturbance, evidenced by confusion, irrational speech, and tendency to lapse into coma. These last several hours, and afterward she has no recollection of them. During the early years of her life, three or four attempts were made to correct the cloaca surgically, which succeeded only in bringing downward the inferior margin of the rectovaginal orifice so that it now lies practically in the fourchette. There is still incontinence except for solid stools, and vulval and perineal soiling and irritation. No sphincter muscle could be felt under the skin and there was no dimple to indicate the position of the absent anus. The operation described was performed December 30, 1935. During the first week there was some inflammation about the stitches closing the vaginal wound, but this subsided without breaking down of the repair, and the rectal suture held also. The child was discharged in three weeks, all wounds practically healed, the rectal orifice and lumen adequate and with practically normal control.

SUMMARY AND CONCLUSIONS

Rectovaginal cloaca of congenital origin with imperforate anus is a well known but rare anomaly. It is associated with incontinence of feces and gas in many instances, with the distressing results of such incontinence, but rarely with high grade obstruction that calls for surgical relief in the early hours of life. It is amenable to very satisfactory surgical correction, and a

method for such correction is herewith described, with a report of three successful cases. It is advisable to defer operative attack until the child approaches puberty, when the anatomic structures are easier to deal with than in the years of infancy.

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DISCUSSION.—DR. WILLIAM E. LOWER (Cleveland, Ohio).—I should like to present a case which is somewhat similar to that reported by Doctor Stone, except that the fistula was between the rectum and the urinary bladder. The child was born with an imperforate anus. I established a colostomy to relieve the acute condition, and then made an artificial anus, closed the fistula between the rectum and the bladder, and then closed the colostomy. The child is now 12 years old; she has no vagina, is almost reaching the age of maturity, and the secondary sex characteristics are developing. The problem now is, what is the next step? Shall I sterilize by roentgen therapy or perform another operation removing the uterus and the ovaries? I am presenting this as a problem. If any one can tell me just what should be done, I should appreciate it very much.

DR. FRANZ TOREK (Montclair, N. J.).—I had a case, similar to the one Doctor Stone presented, upon whom I operated when she was six months old. The fecal soiling was so disgusting that the parents could not tolerate it any longer. The procedure was the same that Doctor Stone has described. The fistula in the back portion of the vagina was closed; the rectum was moved backward and implanted at a new site.

That was 24 years ago. I never heard anything more of the patient until four months ago. She had in the meantime become married and divorced. The reason for the divorce was because of the absence of the perineal muscles, which resulted in loss of sphincteric control over the vaginal introitus.

On examination I found that at the operation when she was six months old, I had paid no attention whatever to the restoration of the perineal muscles. I told her that could be remedied. The operation was performed, and the result is perfect. There is a good sphincteric control. It was also possible to repair the sphincter ani, the anterior portion of which was open. She has since tested the local muscular functions with satisfaction to both parties.

DR. VERNON C. DAVID (Chicago, Ill.).—I think Doctor Stone's operation is a very much better operation than that described by Rizzoli, Delket or de Kermisson, all of whom employed the longitudinal incision, because, as Ombédonne says in his text-book, the rectum in that type of operation tends to return to the abnormal place, so that after a few months or years the situation is very much as it was before operation. I have seen six of these patients, children or infants, with atresia and vaginitis, and have operated upon two of them according to the method described by Doctor Stone, with one or two additions to the technic. Before mentioning them I should like to say that I think it is very important to allow these children to go until they reach the age of five to seven, because in two of these six patients, the rectum and the vagina have spontaneously and naturally separated them-

selves from each other, so that a perineum has formed between the vaginal orifice and the rectum, and the bowel has carried with it the muscles that surrounded the abnormal opening.

In these six children, three have remained continent with the abnormal opening, and if one decides to do an operation to replace the end of the rectum into another situation, which would be considered the normal site, it is very important to be sure that the external sphincter is present, because if the bowel is transplanted into a new place and incontinence develops, the patient will be a great deal worse off than she would have been with the abnormal opening and continence, and I really believe that continence is present in a number of these children.

In transplanting the rectum according to Doctor Stone's technic, you will notice the mucosa is sutured to the skin, and that results in a situation that is commonly seen after opening an imperforate anus, namely, an extrophy of the mucosa results; mucus covers the skin, and it is like a poorly performed Whitehead operation. I think that can be avoided. At least we did avoid it in two patients of this group by making skin flaps from the sides of the new opening of the bowel and allowing them to invert in this new position of the rectum, so that as the end of the bowel tends to retract, as it always does, it pulls these loose flaps of skin in with it. They can be turned in from the side, so that an anal canal lined with skin results, and if enough skin is turned in, it is a very helpful way to prevent stricture, which is another bad result one can obtain from transplantation of these abnormal openings to a new site.

DR. OTTO C. PICKHARDT (New York).—Doctor Stone's presentation has been interesting and instructive. I should imagine that in a good percentage of cases the procedure outlined would be sufficient. However, each one of these cases presents certain individual difficulties which have to be overcome, and where there is a question of a lack of length of the rectum, as in the appended case, which I would like to report, I think a more formidable procedure frequently has to be attempted.

Case Report.—A girl of seven was operated upon in 1928. The cloacal opening represented in Figure 1 is not quite correct. It was really situated well back in the

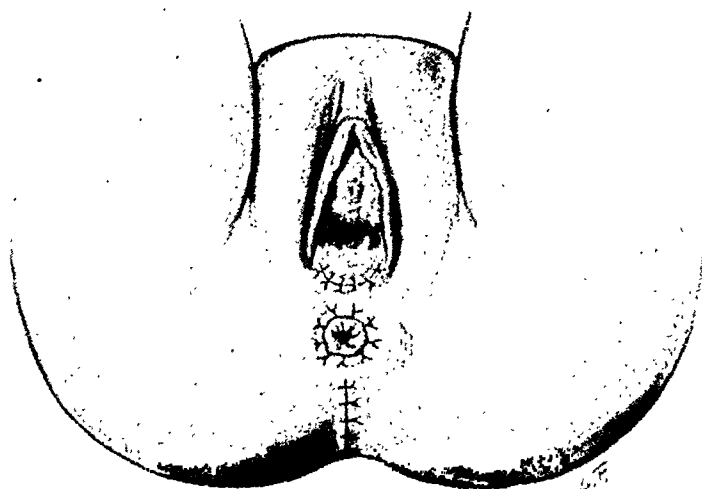


FIG. 1

posterior portion of the vagina. In this case also there was a dimple, but an entirely imperforate anus. The scar is the result of some previous operation (Fig. 1).

It was felt that because of the distance between the cloacal opening and the anal opening, that the simple operation of mobilizing the rectum would not be sufficient, and that a modified Kraske operation would help. Therefore, the usual incision was made, also one around the anal dimple, taking care to leave a bridge of tissue in this particular situation (Fig. 2).

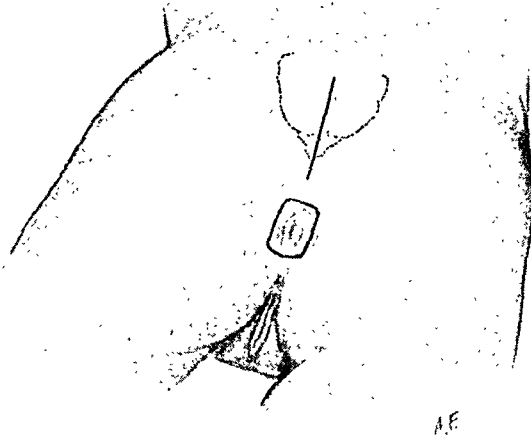


FIG. 2

With the coccyx and a small portion of the sacrum removed, it was an easy matter to mobilize the rectum and to obtain any desired length that seemed necessary at the time. The skin was removed over the anal dimple (Fig. 3). I think it is rather interesting that, in certainly all the cases that I have seen, and in most of those which have been reported, both the internal and external sphincter were almost invariably present.

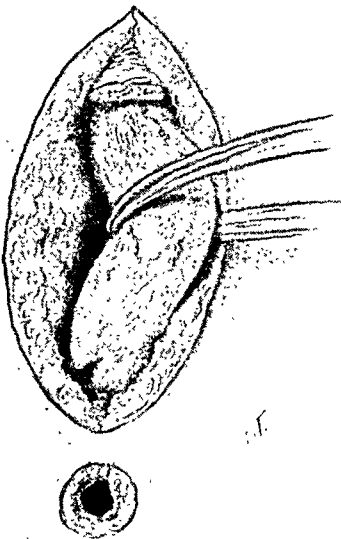


FIG. 3

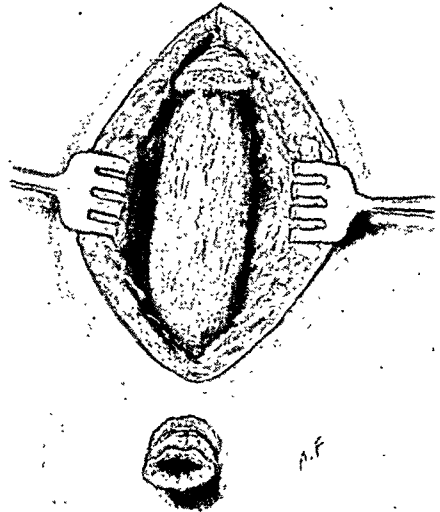


FIG. 4

After complete mobilization the rectum was brought out through the anal opening (Fig. 4). It is wise to leave a large cuff of mucous membrane in order to allow for the retraction that is sure to follow.

The various incisions were then closed, and in this particular instance the opening

in the vagina was so large that the sutures posteriorly could not be placed. The whole vaginal wall, therefore, was brought forward and sutured to the fourchette (Fig. 5).

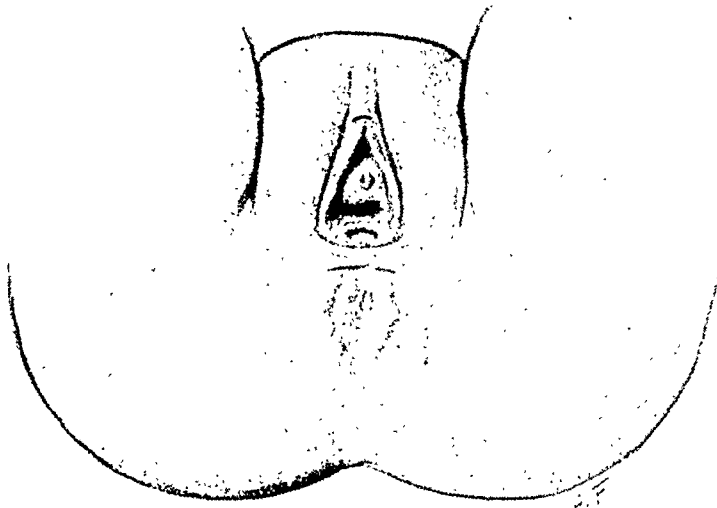


FIG. 5

Another point of interest is the time when the first bowel movement should take place. I waited 13 days in this particular instance. The wounds healed kindly, without infection, and at the end of 30 days the patient had very definite sphincteric control. For the first two or three years, regularly, every month, bougies were passed. At present the child is in perfectly normal condition.

DR. HARVEY B. STONE (Baltimore, Md.) closing.—I think Doctor Pickhardt is right when he says there are much more complicated cases than those I showed, that require extensive and elaborate operations. As a matter of fact I think some of them are probably insoluble.

Such a case, which I referred to briefly, was a patient who had a double uterus, with a very small tubular end of the rectum opening into the very apex of the vaginal vault, between the two cervixes, with no gut below that point at all. I felt that case could not be corrected by any measures that I knew of, but I am sure that some less difficult ones might be corrected by the approach Doctor Pickhardt has described.

I have no answer to Doctor Lower's problem. It would take a wiser man than I to tell him what to do in such a condition. I think Doctor Torek's case emphasizes the advisability of deferring operation in these children until they are out of the infant class, certainly until they are four or five years old, and I believe, better, until they are approaching puberty.

I appreciate Doctor David's suggestion for handling the suture line at the margin of the skin-mucosa anastomosis. I am quite sure that is a valuable addition, and shall employ it at the first opportunity.

OPERATIVE INSULIN CRISIS IN RESECTION OF THE PANCREAS

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COLUMBIA, S. C.

SURGERY of the pancreas has come to the fore during recent years because of the more general recognition of cases of hyperinsulinism. So far, the reports of about 35 such cases coming to operation have appeared in the surgical literature. Because of its rarity each case has taught us something new. The instance which we have encountered is unique in some of its aspects, and teaches a lesson well worth remembering.

The attitude of most surgeons writing on the subject has been that resection of the pancreas for hyperinsulinism is a relatively benign procedure since no fatalities have been recorded. We had the unfortunate experience of operating upon and reporting the first case to die from resection of the pancreas. The cause of death and suggestions of means for preventing similar occurrences in the future form the theme of this report.

Case Report.—W. Y., a Negro male, approximately aged 45, was admitted to Waverly Hospital May 7, 1935. Fifteen years ago he was struck on the head with a blunt instrument and received a laceration on the forehead about three inches long. The skull was exposed but not thought to be fractured. He remained unconscious for about two days, but after three weeks was able to resume work and was perfectly normal, mentally and physically, until the beginning of his present illness three years ago.

Present Illness.—Three years ago he developed a generalized convulsion accompanied by foaming at the mouth, and passed shortly into a stupor from which he could not be aroused. He remained in a semistupor for about two days. Sweating was profuse, and he was cold and clammy during this attack. During the past three years he has had these seizures with the same general pattern at intervals varying from two weeks to two months. His wife could always predict the onset of a convulsion by his confused speech, clamminess of the skin, and beads of perspiration on his forehead. Various mental reactions occurred from placidity to throwing of chairs, attempting to climb walls of room, pulling off clothes, and delusions of persecution. Recovery from an attack would usually take a day or more. His wife claimed that the attacks seemed to occur on days when he had not eaten much, and that she had never seen him have an attack when he was eating normally.

Examination was negative including superficial and deep reflexes, except for a slight scar over the left eyebrow, blood pressure 140/90, and poor oral hygiene. Spinal fluid and blood Wassermann reactions were reported negative.

Course and Laboratory Data.—The diagnosis was not suspected until the fifth day of his stay in the hospital at which time he had a rather typical convulsion with its characteristic prodromal symptoms. Blood for sugar determination was taken at this time, and he was given 35 cc. of a 50 per cent glucose solution intravenously. In about ten minutes he had recovered his normal mental status. The blood was reported to contain 75 mg. glucose per 100 cc. The next day he was found to be cold and clammy; another blood sugar was taken. This was reported to contain 55 mg. After his usual dinner his symptoms disappeared. The following day blood sugar readings were taken before, and a half-hour after, each meal with the following results: 8:00 A.M. (fasting)

—57 mg.; 8:30 A.M.—115 mg.; 12:00 NOON—111 mg.; 12:30 P.M.—105 mg.; 6:00 P.M.—95 mg.; 6:30 P.M.—80 mg. Next day, at the suggestion of Wilder, food was omitted until 5:00 P.M. Sugar at 7:30 A.M. was 50 mg.; at 11:30 A.M.—55 mg.; at 4:30 P.M.—55 mg. No convulsions or untoward symptoms appeared during this period of starvation. The next day a glucose tolerance test was run. *Before the ingestion of 100 Gm. of glucose the blood sugar was 30 mg.; at one-half hour it was 111 mg.; at one hour, 80 mg.; at two hours, 80 mg.; after three hours it had dropped back to the original 30 mg.*

During the next few days the patient was given his regular diet with the addition of intermediate feedings of low carbohydrate vegetables. One chemistry taken at midday during this period showed 36 mg. of sugar. After this disappointing response to diet we began to test his response to drugs. He was given 1 cc. surgical pituitrin, before which the sugar was 36 mg. Fifteen minutes after the administration of pituitrin it had risen to 57 mg. In 30 minutes it had dropped back to 50 mg. Adrenalin was tried the following day. Before administering 10 minims of adrenalin it was 56 mg.; 15 minutes later it was 60 mg.; at the end of 30 minutes it was 50 mg. Atropine was next tried, 1/100 gr. Before, it was 47 mg.; 15 minutes after, it was too low to read (below 20 mg.); a half-hour afterward, it was still too low to read. Because of the rather startling drop, this drug was tried again next day with the following results: Before the atropine, 47 mg.; 15 minutes after, 40 mg.; 45 minutes after, too low to read; one hour after, too low to read. He was tested with physostigmine, the pharmacologic antagonist of atropine. Sugar reading before this drug was 50 mg.; 15 minutes after, 1/100 gr. physostigmine, it was 50 mg.; 45 minutes after, it was 55 mg.; and one hour after, it was 60 mg. It will be noted that this rise is a little higher and longer sustained than that after adrenalin or pituitrin.

Judd assumed that a disturbed vagal control of the pancreas was responsible for its peculiar behavior in spontaneous hyperinsulinism when no tumor was found. We believe that our experiment with physostigmine and atropine raises his assumption to the level of a reasonable assertion.

After this thorough trial with diet and drugs had failed to maintain the blood sugar at a reasonably safe level, and, bearing in mind the possibility that an adenoma or carcinoma of the pancreas might exist, we considered an exploration definitely justified. The operative procedure will be described in some detail to emphasize the fact that it was rather benign *per se* and easy of accomplishment.

Operative Procedure.—After the usual preoperative preparation plus a cup of very syrupy coffee about one half-hour before going to the operating room, he was anesthetized with ether. An upper midline incision, from the ensiform to the umbilicus, was made. The stomach and transverse colon were delivered and a window made in the gastrocolic omentum. The stomach and transverse colon were retracted and a very satisfactory exposure of the pancreas obtained. The anterior surface of the gland was carefully inspected for adenomata, but none was found. The decision was then made that a resection offered the patient his only chance of relief. This we proceeded to do.

The peritoneum was incised near the tail of the organ, and this part gradually freed. As the process of freeing went forward, an anomalous splenic vein with a large, separate pancreatic branch was discovered. This large pancreatic vein was ligated about halfway up the body of the pancreas and further freeing of the body of the organ accomplished without difficulty. Bleeding was minimal. A rubber covered, right angle clamp was placed across the pancreas about midway of the body, and a V-shaped incision made to remove the freed portion. Lock sutures were inserted in the cut surface for hemostasis, and the clamp removed. Two large cigarette drains were placed in the bed of the resected portion and brought through the left part of the rent in the gastrocolic omentum. The cut edges of the omentum were approximated with small catgut ligatures. The closure of the peritoneum was begun and halfway completed when the patient stopped breathing. Artificial respiration was begun, 7½ gr. of caffein sodium benzoate were given intravenously, and 15 minims of adrenalin were injected directly

into the heart. In about two minutes the heart ceased to beat, and, although it was massaged through the diaphragm, the rhythm was never reinstituted. The patient's death was recorded as an anesthetic one until the interesting observations appended were considered.

During the course of the operation 1,000 cc. of a 10 per cent solution of glucose had been given intravenously. This was begun about five minutes after anesthesia had been effected, and was completed in about 20 minutes. Blood for sugar determination had been taken, first, after surgical anesthesia was attained; a second specimen, after the pancreas had been exposed; and a third, after the resection had been completed. They were reported to be 46 mg., 30 mg., and "too low to read," respectively.

DISCUSSION.—This gradual drop to such a level during the operation of resection has not been recorded by other observers, *and is the interesting feature in this case*. Other investigators claim that ether is the anesthetic of choice because it tends to raise the blood sugar. This anesthetic agent, along with 1,000 cc. of 10 per cent glucose intravenously during the course of resection, is generally thought to be positive insurance against the lowering of the blood sugar. The fact that the blood sugar readings in our case became progressively lower would definitely discredit this claim, or certainly prove that it is not universally true. This progressive lowering to such a level made us believe that the cause of death in this patient was a hypoglycemia which, when coupled with the shock attendant to his operation, was incompatible with life and was the immediate or direct cause of his death. It has also led us to suggest that there is an entity, heretofore unrecorded, which we have chosen to call "operative insulin crisis." We suggest that it is due to manipulation of the gland and liberation of an overwhelming dose of insulin into the blood. We do not believe such a lowering of the blood sugar would have occurred independent of this operative procedure in our case while 100 Gm. of glucose were placed at the disposal of his pancreas. If our supposition is correct—that such an entity exists—and we believe that the findings in our case are proof of such a premise, this entity must be reckoned with in future resections of the pancreas. It may be that larger amounts of glucose during the operation will ward off such a crisis. We believe that this entity is a very definite threat against the safety of any patient undergoing similar resection, and that more consideration should be given to the administration of glucose in adequate amounts.

The published reports of end-results from resection of the pancreas have not been encouraging. Isolated reports of good results from radiation of the pancreas have appeared in the recent literature. The latter fact, together with our disagreeable experience with resection and the poor end-results of other observers, has led us to offer the warning that all conservative measures, including roentgenotherapy, should be tried, and that further search should be made for other non-operative measures for the relief of those patients *in whom no tumor is found*. The use of physostigmine, which we report, by inhibiting the function of the pancreas through its vagal control may offer some relief to borderline cases. We believe that further trial of this drug is warranted. Certainly, after a review of the end-results,

we must contend that any other non-operative measures suggested will be more than welcome.

CONCLUSIONS

(1) A case of spontaneous hyperinsulinism, in which death resulted from resection of the pancreas, is presented.

(2) A condition, which we have called "operative insulin crisis," is presented and discussed.

(3) An experiment tending to prove the disturbance in vagal control of the pancreas in hyperinsulinism is described and discussed.

(4) The suggestion is made that the attitude toward resection of the pancreas be tempered with a little more caution and restraint in the future, and that more stringent measures be employed to maintain a safe level of the blood sugar during operation, when it is of necessity performed.

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DISCUSSION.—DR. ALLEN O. WHIPPLE (New York, N. Y.).—It would seem to me that this very interesting case report of Doctor Guerry's is entirely different from the other cases of pancreatectomy that have been reported in the literature. I regret that Doctor Graham is not here to report on his remarkable case and brilliant cure following a partial resection of the pancreas in an infant for hypoglycemia. I know of two other cases, that have not as yet appeared in the literature, that have been entirely relieved of the hyperinsulinism following partial pancreatectomy in which an adenoma was not found. I operated upon a similar case a month ago in a woman of 32 who gave all of the classic findings of hypoglycemia, and who had failed to respond to all forms of dietetic and medical regimens. She was referred to me from the Neurologic Institute of Columbia University. In the course of a very careful exploratory search I was unable to find an adenoma, and therefore resected four-fifths of the pancreas, leaving a small portion of the head. In this patient the rise in blood sugar values was more gradual than I had expected; but in the period of a few weeks the readings have risen from 50 to 75 and the patient has been entirely relieved of her attacks of unconsciousness and hypoglycemia.

In the absence of finding an adenoma in the pancreas itself, a careful search should be made in adjacent organs for an heterotopic pancreatic tissue, particularly in the region of the duodenum, and for a possible Meckel's diverticulum containing pancreatic tissue.

I should like to call attention again to the great advantage of the transverse incision over the vertical incision in these operations for hypoglycemia; and to emphasize again the great superiority of silk technic in operations upon the pancreas.

DR. ROSCOE R. GRAHAM (Toronto, Ontario).—Doctor Gallie and I have had an opportunity to study, in conjunction with our medical confreres, a patient with a history similar to the one Doctor Guerry has presented. We felt we were justified in advising exploration, but at operation found no tumor. This was the first case we have had an opportunity of studying in which no tumor was present. We decided that she should have a resection of the pancreas. In view of the disappointing results which have been reported following such a procedure, we felt we should be very radical, and believed we had left but a very small portion at the end of the operation.

Our estimation of the bulk of pancreas left would be equal to a mass not greater than the distal phalanx of the thumb. We were very much chagrined to find that the weight of pancreas removed, despite what we considered a radical resection, was only 20 Gm. We believed, however, that this must originally have been a very small pancreas.

Our patient, like Doctor Whipple's, did not have an immediate fall in blood sugar. However, at the end of ten days the blood sugar was stabilized at a normal level, and we believed our efforts were likely to be rewarded with relief.

Following the administration of a fairly generous and normal diet, she carried on until the end of the fifth week, when she was again seized with convulsions. It is now about five or six months since her operation, and as far as we can see she is not in the least improved, as compared with her preoperative state.

Professor C. H. Best, who has charge of our Department of Physiology, was good enough to assay the removed pancreatic tissue, and to determine the number of insulin units present. The highest incidence of insulin units in pancreatic tissue which they had previously encountered was 2,500 to 3,500 units per kilogram of tissue. The pancreatic tissue which we had removed assayed 8,000 units per kilogram, which they considered incredibly high.

We are now confronted with a problem more difficult than the original one. I should like to have an expression of opinion from Doctor Guerry as to whether he thinks the removal of a greater amount of pancreatic tissue would have solved our problem. Doctor Whipple's suggestion that we may have missed some aberrant pancreatic tissue may be true; in any event, we failed to recognize it as such.

DR. LEGRAND GUERRY (Columbia, S. C.) closing.—We wished to add this little bit of evidence, in order to accumulate, on this subject, such a body of facts and statistics as to give us some certain, sure path in which to walk. Our experience in operative hyperinsulinism is confined to this one case, and the theme of this paper is the fact that our case presented a feature not yet recorded in the literature on hyperinsulinism. Here is a patient with definite hyperinsulinism, given a large dose of sugar by mouth before operation and after the anesthetic was begun, he was given 1,000 cc. of 10 per cent glucose intravenously, and every one of the blood sugar readings taken during the operation, *i.e.*, after surgical anesthesia had been induced, after the pancreas had been exposed, and after it had been resected, showed a progressive fall and the last reading was "too low to read" (below 20 by the standard used). We are holding this up as a point to be reckoned with in the future handling of this condition and are suggesting that there may be such an entity as "insulin crisis," which may occur in any operative procedure involving extensive manipulation of the pancreas and the liberation of large amounts of insulin into the blood stream.

BENIGN CICATRICAL STRICTURES OF THE BILE DUCTS

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STRICTURES of the hepatic and common ducts are due to a variety of causes which need not now be enumerated. At present, the end-results of operations for benign strictures, due to cicatricial tissue in the wall of the duct, will be considered. Of this type of stricture partial or complete division of the common or hepatic duct in the course of cholecystectomy is unquestionably the most frequent cause. This unfortunate accident, not always due to ignorance or inexperience, may happen to the most skilled surgeon. Abnormalities in the course, length and termination of the cystic duct, and variations in the course, origin and distribution of the cystic artery, fully described by different writers, are important predisposing causes. The pressure of an hemostat on a portion of duct wall, occurring in the attempt to secure a bleeding cystic artery, is also a competent producing cause of subsequent stricture—usually in the hepatic duct just above its junction with the cystic duct. Benign strictures are usually associated with biliary fistulae. When the stricture is acute and complete, as after accidental ligation of the hepatic duct during cholecystectomy, jaundice develops rapidly, symptoms of cholemia and liver incompetency appear, and a fatal issue is averted only by the loosening of the ligature and the formation of a biliary fistula. On the other hand in strictures which form slowly, symptoms of obstructive jaundice are intermittent, appearing when the associated fistula is temporarily occluded. As the stricture tightens after a period of months or years, obstructive jaundice becomes persistent and the patient eventually succumbs to the resulting liver cirrhosis.

As long as the flow of bile through the fistulous tract is unimpeded, the total exclusion of bile from the intestine usually causes disturbances of digestion, the loss of flesh and strength and ultimately a condition of osteoporosis. Exceptionally such exclusion may continue for months or years without impairment of the general health. In the case reported by Moschowitz no bile passed into the intestine for three years; in another case reported by the writer, lasting 100 days, the sole complaint by the patient was the inconvenience of the biliary discharge. In both patients the bile suddenly found its way into the intestine, the biliary fistula remaining permanently closed. This unexpectedly fortunate result was probably due—not to the restoration of the normal duct channel—but to the formation of an adventitious opening in the adjacent intestinal wall by infected bile in much the same way as in the pointing of an abscess.

Symptoms of benign stricture in the absence of previous operation are usually those of the gradual development of jaundice with or without occa-

sional attacks of cholangitis. When pain is present, an impacted calculus in the common duct is the probable preoperative diagnosis. When pain is absent, especially in patients over 40, malignancy in the head of the pancreas is suspected.

Benign strictures vary in their location and extent. Strictures of the hepatic duct just above its junction with the cystic duct, as already mentioned, usually follow cholecystectomy and are localized. Strictures in the common duct frequently due to the cicatricial contraction of pressure ulcers from impacted calculi and limited in extent, are more common at or near the ampulla. Strictures due to septic cholangitis are generally diffuse and may involve the greater part of both common and hepatic ducts.

Operative measures which vary according to the location and extent of the stricture may be arranged in the following groups:

(1) End-to-end anastomosis after excision of the stricture when the orifices of the duct can be approximated without undue tension.

(2) Choledochoduodenostomy when the stricture involves the terminal portion of the common duct.

(3) Hepaticoduodenostomy, -gastrostomy, or -jejunostomy when the stricture involves such a large portion of the common duct that either of the preceding operations is impossible.

(4) Reconstruction of a new duct by the tube method (Wilms).¹¹⁶

(5) Implantation of the biliary fistula into stomach, duodenum or intestine.

(6) Cholecysto-enterostomy in strictures of the common duct when both the gallbladder and cystic duct are normal.

(7) Dilatation of a stricture with the insertion of a buried tube.

(8) Choledochotomy or simple division of stricture.

(9) Hepato-enterostomy, *i.e.*, the approximation of denuded liver tissue to duodenum or small intestine where the stricture involves the hepatic duct within the liver, in which dilatation of the stricture cannot be carried out or has failed to give relief.

While striking results at times have followed each one of these measures with the exception of the last two, failures are not uncommon. Either the stricture recurs within a year or earlier, or a septic cholangitis, of increasing intensity eventually proves fatal. Recurrence of the stricture is less likely if, in the operative anastomosis, the mucous membrane of the divided ends of the duct or of the duct and intestine can be approximated and sutured without tension. The absence of infection then favors primary union, and, if the line of suture is not torn apart by the later withdrawal of the tube from within the duct, stricture ought not to recur.

If the ends of the divided duct or of the duct and intestine cannot be properly approximated, the resulting gap may be bridged by the insertion of a rubber tube which is then invested by omentum. There is some evidence to show that the granulation tissue encircling the tube becomes lined by the

extension from above and below of the normal epithelium of the duct and if, in the case of obliteration of the common duct, the tube extends from the hepatic stump into the duodenum, by the extension of the duodenal epithelium upward as well. The capacity of cells lining mucous membranes to proliferate and to extend over adjacent granulating surfaces has long been unquestioned. Doctor Rohdenburg of the Lenox Hill Hospital told the writer that, ten years after the establishment of a gastric fistula for a stricture of the esophagus, the excised fistulous tract differed from the mucous membrane of the stomach only in that the submucous glands were more "stumpy" in character. He also called attention to the fact that, in complete fistula in ano, the fistulous tract becomes lined by an extension of the rectal mucous membrane from within outward and by an extension of the epidermal cells from without inward. Phemister⁸⁶ of Chicago has also demonstrated the extension of epidermal cells over the granulating surface of an osteomyelitic cavity in the lower end of the femur. Such cellular proliferation is shared by the lining epithelium of the hepatic and common ducts and the duodenum. Assuming that a segment of a bile duct can be reconstructed in this way, such a reconstructed duct ought not to undergo any marked diminution of its lumen through the contraction of the organized granulation tissue of which it is in large part composed. That such extension does not always occur, however, has been shown by Colp,¹⁶ who bridged an interval between the divided ends of the common duct with a rubber tube invested by two layers of connective tissue of the gastrohepatic omentum. Sixteen months later the patient died of myocarditis without return of any symptom of biliary obstruction. On autopsy the reconstructed segment of duct was found to form a canal epithelially lined but smooth walled, and without the usual duct structure. There was no stenosis or narrowing. On microscopic examination the reconstructed segment consisted of dense laminated connective tissue covered by one layer of flat spindle cells. The absence of any stenosis in this case is of the greatest interest. On autopsy in Freeman's case, the reconstructed part of the duct was patulous although small, about the size of a "broom straw," but fluid could easily be injected through it.

Similarly, the wall of a biliary fistula is supposed to become lined with epithelium by extension of the mucous membrane of the duct and by the duodenum as well, if it is connected with that structure. In Jenckel's case the external orifice of the fistula became lined with duodenal epithelium within 11 days. He also emphasizes the capacity of the epithelium of the duct to grow and thinks that this process is hastened by its dilatation. Unfortunately in his second case which succumbed 12 years after a reconstruction operation, the autopsy record failed to mention any microscopic examination of the reconstructed duct. It stated, however, that two centimeters below the transverse fissure of the liver a callous like mass was found in which no canal could be identified macroscopically. The hepatic tributaries were not dilated and he was of the opinion that the reconstructed duct functioned to the end, and that cirrhosis of the liver, together with amyloid degeneration of the kidneys and spleen, caused the patient's death.

Roeder⁶⁰ of Omaha has made a valuable contribution to this subject. Before implanting a biliary fistula of four months' duration into the duodenum, the terminal $1\frac{1}{2}$ cm. of this fistulous tract were excised; examination showed patches of columnar epithelium and gland like structures resembling more the mucous membrane of the duodenum than that of the common duct. On the other hand, Cave reports no epithelial lining in the wall of a biliary fistula 106 days subsequent to its formation.

Recurrence of stricture may be due to errors in the use of the rubber drain. Thus, after end-to-end suture over a T tube emerging through the line of suture, stricture may follow if, in its withdrawal, the ends of the duct, already advanced in union, are torn apart. To diminish the risk of this accident the writer suggested the use of collapsible or soft rubber, around which a strong piece of silk, firmly tied, was brought out of the abdominal incision. In two cases treated in this manner the withdrawal of the tube was evidently harmless as all discharge of bile ceased within 48 hours. In suture of a duct, incompletely divided, the tearing apart of the line of suture is less likely to take place. The writer also suggested the bringing out of the tube through a separate opening in the wall of the duct either above or below the line of suture. This procedure has been practiced by a number of surgeons including Horgan⁴⁸ of Washington, who advocates the use of a special L shaped tube. The divided duct is sutured over the inserted shorter limb of this drain, while its longer limb, making an oblique angle with the shorter limb, emerging at the separate orifice, is then brought out of the abdominal incision. Horgan reports three brilliant results in which this technic had been employed. Dr. S. W. McArthur,⁷⁶ in place of a T tube, uses an L shaped tube passing upward in the choledochus with a small rubber catheter passing through the same opening down into the duodenum. The latter can be utilized for irrigation and medication.

The use of a rubber tube so large as to unduly compress the mucous membrane of a duct, into which it has been inserted, must be avoided. Too stiff rubber tubes are also objectionable, as their withdrawal from the duct is liable to rupture a line of suture, or may damage the wall of a reconstructed duct, if that method of duct repair has been attempted. Furthermore, the extremity of such a tube, if it becomes disengaged, may produce pressure necrosis of the wall of a hollow viscus. Von Redwitz¹⁰⁰ (personal communication) related a case in which an ulcer of the stomach was caused in this manner, and Roeder a case (personal communication) in which the end of a 14 cm. catheter, over which a biliary fistula had been anastomosed to the duodenum, passed two months later, through the anastomosis or wall of the duct, into the peritoneal cavity, and about three months afterward penetrated the pelvic sigmoid, causing a fatal peritonitis.

In duct reconstruction with a buried tube, the retention of the tube as well as its removal when the duct is fully formed presents certain difficulties. It was at first hoped that the buried tube would remain permanently fixed in position or that it would ultimately disintegrate. It was found, however,

that a tube so fixed usually became blocked in the course of a few months or possibly years with precipitated biliary sediment which also coated its outer surface, causing recurrence of jaundice which was relieved only by the removal of the tube. Shenstone, of Toronto, advocates the monthly instillation of two or three drops of sulphuric ether to keep a permanent "T" tube free from precipitated sediment. In a case cited this has proved effectual over a period of two years. Cases of this accident have been reported not infrequently, including one instance (Judd⁵⁴) in which such an incrustated tube remained in situ for six years. Premature discharge of the tube, predisposing to a recurrence of the stricture, may be prevented by the suture of its upper extremity to the wall of the hepatic stump, nonabsorbable material being used. L. L. McArthur⁷⁵ endeavored to secure the same result by forming a reverse cuff on the end of the tube which then ordinarily remained in situ for four or five weeks.

To prevent its premature discharge and to permit its removal at the will of the surgeon the following technic is suggested by Voelcker.¹⁰² The buried tube attached to the hepatic stump above, and in the absence or obliteration of the choledochus, penetrating the duodenal wall (Witzel) below, is then brought out through a separate opening in the anterior duodenal wall (Witzel), and through the abdominal incision, to the edge of which it is firmly attached. This measure has been employed to a limited extent by surgeons abroad with variable results. The possibility of a duodenal fistula is obvious. If, as a result of the operation, the passage of duodenal contents is obstructed by its acute angulation, a posterior gastro-enterostomy is added.

One of the most frequent, and justly dreaded complications, common to all operations for the relief of benign stricture, is cholangitis. This complication, if mild in character, occurs in occasional attacks of short duration during the first year or two after the operation and then ceases. It is probably due to temporary swelling of the duct at the point of suture. The more severe cases are due to infection, the source of which is still unsolved. The fact that it seems to occur with greater frequency the more remote the anastomosis is from the papilla, points to an intestinal origin. That it may arise within the biliary tract is also quite probable. Cholangitis is unquestionably favored by any obstacle to the outflow of bile. Efforts to eliminate this unfortunate complication by making the anastomosis between the biliary and intestinal structures, in a loop of gut from which the normal intestinal current has been diverted, have not diminished its frequency. Irrigation of the duodenum both before and after operation with a solution of magnesium sulphate may be of some value. Douglas¹⁸ has suggested the administration of large doses of bile salts and Williams the administration of ox gall in order to diminish the fetid character of acholic stools, and more recently the use of secretin to promote the flow of bile has been suggested by Prewitt.

Before proceeding to a review of the end-results of the different operations for the relief of benign stricture, it is important to emphasize that extensive adhesions between the parietal peritoneum, omentum, the edge of the liver, the pylorus, duodenum, and the hepatic flexure of the colon, obliterate

anatomic landmarks and make the exposure, recognition, and orientation of the stricture hazardous and difficult. Discretion may therefore be the better part of valor, particularly in recurrent strictures when biliary cirrhosis, and possibly infection, have impaired the function of the liver. Under such circumstances after biliary drainage has been established the actual reconstruction of the duct may be advantageously postponed to a later time when the jaundice has subsided and the function of the liver has, at least, been partially restored. The frequency with which strictures recur, each recurrence requiring further operation, is a common experience to all. Usually more than one and, at times, as many as five or six attempts have been made to relieve the patient in the course of two or three years. This multiplicity of operations at least testifies to the ability of patients with damaged biliary tracts to endure formidable operative procedures.

The writer has collected 38 cases of duct reconstruction by end-to-end anastomosis reported in surgical literature and from personal communications of colleagues in this country and abroad. While failures have not been infrequent, the number of successful end-results is most gratifying. No less than 14 patients have remained well from ten to 19 years and ten others from five to ten years. In each instance the patient, if living, was symptom free at the end of the period of observation. Three patients (Stetten,⁹⁵ Downes¹⁹ and Eliot²²) died from intercurrent disease at the end of 19, ten, and 18 years respectively. It is consequently not unreasonable to conclude that the relief may be considered permanent, if patients have remained free from recurrence for five years. Patients who have remained well for ten years or longer include those operated upon by Douglas¹⁸ (two cases), Matthews,⁶⁵ Downes (two cases), Homans⁴⁷ (two cases), Riggs,⁸⁹ Schweizer,⁹⁴ Papin,⁸³ Horgan, Stetten, and Eliot²³ (two cases). Many of these, in whom the relief may be said to be permanent, suffered from mild attacks of cholangitis for the first and second year after operation. In one of them—active and in good health at the end of 13 years (Downes)—these attacks persisted for three years after operation and, at the present time, indiscretion of diet is usually followed by a short “bilious” attack. In both cases reported by Douglas (well 11 and 14 years after operation) these attacks occurred, in one, not until the second year after operation. Similar experiences have been had by Matthews, Stetten, Seward Erdman,²⁷ and Eliot. In Erdman’s case the attacks still continue, though with decreasing intensity, three and two-thirds years after operation.

Exceptionally attacks of cholangitis have been so severe as to have proven fatal. A patient of McArthur’s succumbed 18 months after operation and Fiolla’s patient, after remaining free from cholangitis for two years, died subsequent to a particularly vicious attack. In one of Judd’s patients an abscess of the liver developed which was, however, successfully drained. The fact that mild attacks of cholangitis frequently subside after a year or two justifies conservative treatment. Only when they increase in frequency and intensity with persistent and deepening jaundice is further operation indicated.

HEPATODUODENOSTOMY.—To the 41 cases here reported of hepatoduode-

nostomy, performed by various surgeons, must be added 15 reported by Walters¹⁰³ without detail, one being alive and well five years after the operation, and several others for shorter periods. Of the 41 cases, 11 remained well for from ten to 20 years. The fact that these patients were symptom free at the end of the period of observation justifies the conclusion that the cure may be considered permanent. As in cases treated by other methods, cholangitis was a frequent postoperative complication. In the case reported by Leriche,⁶⁰ the attacks of cholangitis which ultimately caused the patient's death did not become severe until two and one-half years after operation. Septic cholangitis, terminating fatally from abscess of the liver, was also observed in Melchior's⁶⁹ patient.

Usually leaving a small tube in the anastomotic opening for a considerable period of time after operation, at least for several months, is advocated, and to its early passage recurrence of the stricture has been ascribed. J. F. Erdmann²⁵ removed a tube completely blocked with precipitated biliary material five and one-half months after operation, and Judd, in a patient who developed cholangitis four years after operation, removed a calcified tube six years after the hepatoduodenostomy. This is by far the longest record found in which the tube has remained in situ. On the other hand, some surgeons advocate anastomosis without a tube or its early removal. Anastomosis, in which the respective mucous membranes can be approximated without undue tension, offers a favorable condition for this method of treatment. In Moritz Cohn's¹⁵ case in which the patient was symptom free at the end of 12 years, the tube was removed on the twelfth day.

The first successful operation of hepatoduodenostomy was probably performed by W. J. Mayo⁷¹ in 1904. Fifteen years later this patient was symptom free. It is a pleasure to call attention to the striking success of LeGrand Guerry,⁴¹ who relieved seven consecutive patients without a death and, so far as is known, without symptoms of recurrence. This surgeon modestly expresses a preference for hepatoduodenostomy rather than for choledochoduodenostomy, as two patients, earlier operated upon by the latter procedure, succumbed to pneumonia and cholemia respectively. No other surgeon has enjoyed such freedom from mortality.

Choledochoduodenostomy.—Twenty-seven cases of this operation for stricture, gathered by the writer from the literature and personal communications, include a number in whom sufficient time has not elapsed to determine the final result. Two patients (Behrend⁵ and Peterman⁸⁵) were symptom free 19 and 12 years respectively after the operation. Two others (Finsterer and Guerry) were symptom free six years after operation. Caves'¹⁴ case, in which the anastomosis was done with a Murphy button, was well nine years afterward. Several others were symptom free for shorter periods. The fact that stricture is more common in the hepatic duct, owing to the greater frequency of accidents during cholecystectomy, probably accounts for the relatively small number of cases of this type. The number is sufficient, however, to prove that, as in other operations for stricture, cholangitis is a common, though perhaps a later and less severe, complication. In Downes' case, death

did not occur until six years after the operation and an equal time elapsed in the case reported by Sasse⁹¹ in which, at the time of operation, a pneumococcus infection of the duct was present. In Judd's case an abscess of the liver was successfully drained, the patient being well three years afterward.

To determine the exact nature of the stricture—whether cicatricial or inflammatory—when situated at or near the ampulla, is much more difficult than in strictures in the more accessible portions of the hepatic or common ducts. In both conditions choledochoduodenostomy is justifiable. If the stricture is cicatricial, the anastomotic channel is permanent; if inflammatory, the new channel, providing adequate drainage as long as the stenosis continues, is probably gradually eliminated when the patency of the duct is restored. Such restoration is graphically demonstrated in an autopsy reported by Finsterer, the patient dying from cancer of the cecum six years after a choledochoduodenostomy. The patency of the common duct had been restored and no trace could be found of the anastomotic opening.

It is also of interest to emphasize the low mortality of this operation which has been strongly advocated by Sasse, Flörcken,²⁹ and Peterman as a means of providing internal drainage in place of a T tube or a buried tube after an ordinary choledochotomy. Sasse reports 46 cases without mortality, and of the 20 reported by Flörcken, only one died from peritonitis due to suture insufficiency. Sasse and Peterman call attention to the fact that this operation is contra-indicated by undue friability of the wall of the duct and by the presence of its cystic dilatation. External drainage is preferable in the presence of cholangitis, of calculi or precipitated bile in either the common or hepatic duct. Flörcken adds the presence of ascarides, a narrow common duct, and beginning atrophy of the liver. Under all other conditions its low mortality and excellent results justify the general adoption of this operation which, hitherto, seems to have been employed solely by the above mentioned surgeons.

Formerly the ease with which duodenal contents could enter the duct after choledochoduodenostomy was thought to predispose to the danger of an infectious cholangitis. Latterly, however, this fear has been dissipated by the fact that, after a choledochoduodenostomy, in numerous instances, barium, introduced into the stomach, has been found to penetrate to the hepatic tributaries, with no indication of even mild cholangitis and, in the case reported by Hunt,⁵¹ air in these same vessels was demonstrated roentgenologically three years after operation. It is also of interest to point out that duodenal contents have regurgitated through the opening in the common duct and have emerged through the abdominal incision after a simple choledochotomy. Codman was the first to report such an occurrence and latterly Walters¹⁰⁵ has added four other instances in which the ampulla was not subjected to any operative measure. In each of these five cases, however, the patency of the ampulla was demonstrated by the passage of a probe or of a uterine sound (Codman), and this may have caused temporary paralysis or relaxation of the sphincter of Oddi. Even, however, without instrumentation or any opera-

tion whatever, this sphincter is not always competent. Such an instance was demonstrated by my associate, Doctor Jennsen, who found the common duct distended with barium in an ordinary roentgenologic investigation of the duodenum.

TRANSPLANTATION OF BILIARY FISTULAE.—The writer has collected 41 cases of implantation of biliary fistulae into the stomach or intestine, from a search of the literature and from personal communications with surgeons here and abroad. Of these, 29 patients were operated upon in this country and six in Germany. In 18 the fistula was transplanted into the stomach, in one into the jejunum, in the remainder into the duodenum. The unfortunate experience in four cases observed respectively by von Stubenrauch,⁹⁹ Cahen,¹³ Heidenhain, and Dobrotworski,¹⁷ in which, after several weeks, a rapid contraction of the opening of the biliary fistula into the stomach was demonstrated either by relaparotomy or autopsy, has led these surgeons to conclude that implantation of the fistula into that organ should be avoided. In this country contraction of the biliary fistula proper has sometimes been observed, as in one of Walter's¹⁰⁶ cases, in which such a contraction developed four months after the implantation of a biliary fistula into the stomach, and a second time in the same patient, five months after the operation had been repeated. Also in Vincent's case, contraction of the biliary fistula followed its implantation into the duodenum. On relaparotomy, only a small probe could be passed through the fistulous tract which, after being dilated to the size of 14 F, was again implanted into the duodenum. The patient suffered from repeated attacks of cholangitis and died three and one-half years after the first operation from cirrhosis of the liver with enlarged spleen. Vincent's comment on the value of this operation follows: "That a partial result that begets cirrhosis is not worth while. When possible I should endeavor to unite the mucous membrane of the duodenum to that of the divided duct in the hope that, if the patient survived this more formidable procedure, life would be worth while." In the cases reported by Lahey,⁵⁹ several failures were due to repeated attacks of cholangitis with, in one instance, the filling of one-half of the abdominal cavity with an enlarged liver, the patient, subsequent to the operation, being invalided the greater part of the time. The occurrence of this unfortunate complication in cases reported by Lahey, Vincent, Walters,¹⁰⁷ Judd and others, proves that ascending infection may extend along the course of a biliary fistula and thence along the duct with which it communicates, to the parenchyma of the liver. Notwithstanding a brilliant result in which the patient was symptom free 15 years after the operation, Lahey comments rather pessimistically as follows: "It is my opinion that the operation is bound to be followed by a good many failures as it is really a makeshift procedure. More and more I become convinced as does everybody else that the procedure offering the best chance is, if possible, direct anastomosis of the duct." More encouraging results are reported by Russell,⁸⁸ whose patient was symptom free four and one-half years after operation, by St. John, whose patient was still symptom free when he was lost track of three years after

operation, by Lilienthal, whose patient died from cancer of the stomach four years after operation without any indication of biliary trouble, and by Roeder,⁹⁰ whose patient, at the end of seven years, suffered only from slight attacks of indigestion. Masson's patient died, symptom free, nine years after implantation, from cerebral hemorrhage, and Walter's three cases were in excellent health two, two and three-quarters, and three and one-half years respectively after operation. The most striking case of all is the patient of Hugh Williams who at present, 23 years after operation, enjoys perfect health. The fact that, in this case, the implantation was done when the patient was only four years old may account for the satisfactory epithelization of the biliary tract that must have taken place. In Lilienthal's case, in which, unfortunately, there was no autopsy, the implantation of the fistula with a collar of integument may have been a factor in the development of the malignant growth.

Abundant blood supply in the wall of the fistulous tract decreases the danger of its ultimate contraction. Its dissection, therefore, should not be carried beyond the free border of the liver and it should be only sufficiently long to insure anastomosis without undue tension. It should be coned out in such a way that its circumference increases as its deeper portion is exposed. A period of at least three months is essential to insure adequate vascularization of the wall of the fistula.

THE WILMS-SULLIVAN OPERATION.—In this country the credit of originating this operative procedure is quite properly given to Arthur G. Sullivan⁹⁶ who conducted his preliminary research in 1907. Abroad, where the operation has been more frequently employed, it is usually referred to as the "Wilms operation."¹¹⁶ As a matter of fact Prof. Jenckel of Altoona should be given the chief credit, as he performed this operation in 1905 upon a patient aged 52, who still enjoys excellent health without the slightest evidence of recurrence.

The newly formed wall of the reconstructed duct must be composed, as far as is practicable, of immobile contiguous tissue. If the great omentum is employed for that purpose, only such portions as are not susceptible to the movement of the transverse colon, or likely to change position from pressure of adjacent viscera, should be utilized, for any movement whatever, if it does not actually endanger the integrity of its wall, may easily result in unfortunate angulation of the reconstructed channel.

Thirty-five cases are herewith reported. Of these, abstracts of the histories of five patients operated upon by Wilms, one by Jenckel, and one by Sullivan were presented by the writer in 1917. With few exceptions, the results are discouraging and more than one surgeon abroad has discarded the operation.

Unquestionably the most brilliant result was that obtained by Jenckel,⁵³ whose patient, reported in the *Deutsche Zeitschrift*, vol. 95, was alive and well, in full possession of her faculties, at the age of 82, 30 years after the operation. Another patient reported by the same surgeon suffered from

attacks of cholangitis for six years after the operation, which invariably yielded to medical treatment. The attacks later on became more severe, although at one time, 11 years after the operation, the patient's condition was excellent, and she was free from jaundice. However, a relapse followed and the patient died a year later. On autopsy the liver was cirrhotic with an abscess in the right lobe. The reconstructed duct was patent, though somewhat narrowed. Professor Jenckel believes that death was due to the cirrhosis and its associated lesions. A third patient operated upon by Jenckel was symptom free at the end of four years, when he was lost sight of. Sullivan's patient died from cancer of the colon eight years after the operation of duct reconstruction. Hagler reports a case in which death occurred seven months after duct reconstruction by the passage of a tube from the hepatic stump into the duodenum, the cause of death being abscess of the liver.

It is therefore obvious that this method of duct reconstruction is also subject to both mild attacks of cholangitis and to the more serious results of an ascending infection.

In Jenckel's brilliant case, a tube the size of an index finger was used. Although this may increase the possibility of a duodenal fistula (which actually occurred in this patient), it is quite probable that the use of a large tube insures a larger caliber of the reconstructed duct and thereby diminishes the chance of its subsequent contraction.

HEPATOJEJUNOSTOMY.—Nordmann⁸⁰ reports a case in which this operation was performed for a stricture following an immediate end-to-end anastomosis of a divided duct. The patient died three years later from septic cholangitis. Nordmann also mentions four other cases of which three were well several years after the operation, the fourth dying of septic cholangitis at the end of a year.

Enderlen²⁴ reports a case in which the patient was symptom free at the end of 11 years. In this instance the operation was supplemented by a Brauns anastomosis. Enderlen also reports a second case in which this operation, with the same modification, was done after the failure of a previous hepatoduodenostomy. An autopsy on the eighth day after operation disclosed an abscess of the liver, evidently of some months' duration, with a complete obliteration of the original anastomotic opening.

The seven cases in which this operation was performed are too few to permit drawing any definite conclusions as to its merit. Anastomosis of the duct to the jejunum is thought by many to increase the chance of subsequent serious cholangitis. To minimize this risk Enderlen added a Brauns anastomosis, the stump of the hepatic duct being inserted into the extruded segment. The fact that cholangitis does not always develop after this operation is demonstrated by the brilliant result in one of the patients reported by that surgeon, who was symptom free 11 years later. Hepatojejunostomy is indicated chiefly when the hepatic stump cannot be approximated to either the stomach or duodenum without undue tension. Under such conditions it is

considered preferable by some surgeons to reconstruct the duct by the Wilms' procedure, as well as to implant the biliary fistula.

ANASTOMOSIS OF THE ORIFICE OF A BILIARY FISTULA TO A SEGMENT OF JEJUNUM FROM WHICH THE INTESTINAL CURRENT HAS BEEN DIVERTED.—August Hildebrandt⁴⁵ suggested and carried out the following procedure. After division of the upper jejunum, intestinal continuity is reestablished by anastomosis of the oral segment to the jejunum at about 10 cc. below the point of division. The distal end of the divided jejunum is then brought out through the abdominal incision and after being passed through a tunnel behind the rectus muscle, is approximated to the mouth of the biliary fistula. A short tube is placed in the anastomotic opening and left in situ for four weeks. The patient upon whom this operation was performed died five years later in a condition of extreme icterus. Autopsy showed a large abscess beneath the liver into which both hepatic ducts opened. The abscess communicated with the intestine by a small channel, the opening in the gut being the size of the head of a pin.

Dobrotworsky¹⁷ reports a case in which the loop of jejunum, after being placed within 2 cm. of the orifice of the biliary fistula, was temporarily closed. After ten days a small opening was made in it and a tube inserted joining the two orifices. Nine years afterward the patient was symptom free. He states that the "Patient attends to the fistula in the following way. Once a month the tube is removed and replaced by a duplicate. A small gauze bandage is sufficient to absorb the slight discharge. During the past year the mucous membrane of the jejunum slightly prolapsed with an increase in the amount of mucus. There has been no attack of cholangitis during the entire period nor any tendency for the fistula to contract." He also reports a second case, symptom free after five years, in which peristaltic activity of the intestine tended to expel the connecting tube. This was relieved by the insertion of a longer drain.

Gonterman³⁸ (personal communication) writes that in one case in which the above operation was done the result was good. No further details were given. He also writes that a second patient died from strangulation of the loop brought out through the abdominal incision, due to angulation with consequent constriction of its blood supply, and warns against the occurrence of this accident.

Braeünig¹¹⁹ (personal communication) describes a modification of this procedure as follows: After reestablishing intestinal continuity in the above manner, the biliary fistula is coned out and anastomosed to the open orifice of the divided jejunum. Recurrence of the symptoms of stricture in a patient subjected to this procedure occurred a half-year later. On relaparotomy, complete closure of the biliary fistula was found together with a large accumulation of bile in the retroperitoneal epigastrium. Duct reconstruction over a T tube between the upper choledochus and the duodenum was accomplished. Twenty-one months later patient was symptom free.

ANASTOMOSIS OF THE HEPATIC OR COMMON DUCT TO THE STOMACH.—Dr. Paul Tschassownikoff⁹⁷ of Odessa reports a case of anastomosis of the hepatic stump over a small tube with the pylorus, preceded by denudation of a pyramidal shaped area in the adjacent liver to promote, by adhesion, a barrier against leakage. This patient was symptom free 14 years after operation (personal communication).

Schweizer:⁹⁴ Recurrence followed the above operation within a year, due, he thinks, to the too early passage of the tube (five weeks). The operation was repeated over a T tube which remained in situ for a year. During this time there was occasional bleeding around the tube, which was replaced by a catheter. Death occurred from hemorrhage three years after the second operation.

Walzel:¹¹¹ Hepatogastrostomy with tube brought through stomach wall (Witzel). Repeated five times in two and one-half years for recurrence: Death from nephritis and inanition.

Lewis¹²⁰ reports a case with an immediate satisfactory result of anastomosis between the orifice of a biliary fistula in the stomach and the hepatic stump. Sufficient time has not elapsed to determine the end-result.

CHOLEDOCHOTOMY FOR STRICTURE.—Schweizer and the writer report respectively cases of this operation for the relief of stricture. In Schweizer's case the patient was symptom free 14 months after operation and in the writer's case the patient was lost track of about 18 months after operation. There had been in the interval one mild attack of cholangitis. Mere division of a benign stricture temporarily relieved obstruction. Were subsequent dilatation possible the result would be most satisfactory. Recurrence of the stricture, however, can be prevented only by the insertion and retention of a rubber tube. A stricture at the ampulla was divided by Fründ from within the duodenum and a rubber tube inserted which remained in situ for two years, during which time the patient suffered from attacks of cholangitis. On relaparotomy the duct was found widely distended above an incrustated tube, which was removed and a choledochoduodenostomy performed. Nine years later the patient was symptom free.

Postoperative complications include hemorrhage, shock, peritonitis, due either to leakage or to infected bile, acute pancreatitis, subdiaphragmatic abscess, septic cholangitis with abscess of the liver, septic thrombosis of portal radicals with or without mesenteric thrombosis, and finally terminal cirrhosis with occasionally splenic involvement. The presence of noninfected bile in the peritoneal cavity is dangerous only when it distends the lesser peritoneal cavity or when it accumulates between the dome of the liver and the diaphragm (Leriche and Walters) with consequent pressure downward on the liver and interference with the flow of blood through the hepatic vein. Accumulation of noninfected bile in the greater peritoneal cavity is well tolerated. J. F. Erdmann removed several gallons 14 days after cholecystectomy; a fortnight later a successful choledochoduodenostomy was performed. The writer also recalls the accumulation of a large amount of biliary ascitic fluid after a subcutaneous rupture of the liver, which was removed by aspiration two weeks

after the receipt of the trauma. In neither case was the condition of the patient serious and in both recovery promptly ensued.

Accurate estimate of the relative value of these different operative procedures is impossible. In general the selection of the more simple operation is indicated. End-to-end anastomosis, when practicable, after excision of the stricture, affords an excellent chance of success. In strictures of the common duct, choledochoduodenostomy, or hepatoduodenostomy, especially where the mucous membrane of the duct can be approximated to that of the stomach or intestine without tension, is evidently the operation of choice. Duct reconstruction by the Wilms' method has not usually given encouraging results. Implantation of biliary fistulae into the stomach or duodenum appears preferable. Either one or the other of these two procedures or an anastomosis of the duct with the jejunum must be attempted when the greater part of the hepatic and common ducts is obliterated. Treatment of strictures of the hepatic duct within the liver still present a most difficult problem. An attempt should be made to establish a fistula with the dilated portion of the duct or with a segment of liver parenchyma, previously penetrated with the cautery, which subsequently may be transplanted into the stomach or duodenum. The few attempts of anastomosis of the duct or fistula with a loop of jejunum, from which the intestinal current has been diverted, do not justify an estimate of the value of this particular method of treatment.

In conclusion it is a privilege and pleasure to acknowledge the kindness of colleagues abroad and in this country for their painstaking cooperation. Without these courtesies the preparation of this paper would have been impossible.

ABBREVIATED CASE REPORTS

WILMS' OPERATION

Wilms-Brandt:¹¹⁰ Entire common duct obliterated. Well 15 months later.

Wilms-Brandt: Tube from hepatic stump into duodenum. Well 15 months later.

Wilms-Brandt: Tube from hepatic stump into duodenum. Well one and one-half months later.

Wilms-Brandt: Tube from hepatic stump into stomach. Well six months later.

Wilms-Brandt: Tube from choledochus into duodenum. Well one and one-half months later.

Hagler:⁴¹ Seven months after reconstruction with tube, death occurred from abscess of the liver.

Naegele:⁷⁸ Tube from duct into duodenum followed in several weeks by stenosis of duodenal orifice, relieved by plastic. No end-result mentioned.

Magnus:⁶⁸ Reports two operative deaths.

Simon:⁶⁸ Reports a case complicated after operation by abscess around the choledochus. Prefers direct anastomosis of duct to stomach or duodenum.

Enderlen: Reports an operative death.

Feist:³⁸ Gap 4 cm. long bridged by tube from choledochus into duodenum. Symptom free one year after operation; then (personal communication) recurrence with swollen liver and probable death.

Sullivan: Reconstruction with tube for stricture 1½ cm. long. Died eight years later from cancer of the cecum without sign of recurrence.

Jenckel: Gap 7 cm. long bridged by tube, the size of index finger, from hepatic duct into duodenum. Mild cholangitis for several months, then symptom free. Patient, now aged 82, is well 30 years after operation.

Jenckel: Gap 7 cm. long bridged with tube. For six years postoperative had mild attacks of cholangitis, which yielded to medical treatment. Eleven years after operation symptom free. Then jaundice with death a year later. On autopsy the duct was patent though somewhat narrowed. There was an abscess in the liver. Cirrhosis, to which Jenckel ascribed the death of the patient. No microscopic examination of the duct was made.

Jenckel: Gap from duct divided during cholecystectomy was bridged for a distance of between 3 and 4 cm. Stricture formed after six months. Relaparotomy disclosed the tube between a cystic dilatation above and the choledochus below. Death occurred from biliary peritonitis.

Jenckel: Gap of 3 cm. during cholecystectomy. Bridged by tube. Four years later, when patient was lost sight of, there was no sign of recurrence.

Erdmann, J. F.:³⁰ Gap from division of the duct during cholecystectomy. Bridged by tube which passed in five weeks. One year later recurrence of stricture was relieved by hepatoduodenostomy. Patient well five years later.

Jenckel: Refers to six additional cases in which this operation was performed without a single failure.

Whipple: Wilms' operation bridging a gap between the hepatic duct and duodenum. Patient relieved for four months. Then recurrence. Subsequent operation failed to re-establish the duct continuity into the duodenum. Patient died two years after the original operation.

Franz, C.:³¹ Reports two cases followed by stricture.

Brin, H.:⁷ Tube bridging hepatic stump and duodenum. Condition good one year later.

Savariaud:⁹² Tube bridging hepatic stump and stomach. One year later condition fair. Some attacks of cholangitis.

Gernez:³⁷ Tube bridging hepatic stump and stomach. Recovery. No end-result given.

Tuffier: After tube operation symptom free for two years. Then progressive cholangitis with death notwithstanding a biliary fistula.

Lobmeyer:⁶² Tube bridging hepatic stump and duodenum. No end-result given.

Hübsch:⁵⁰ Tube bridging hepatic stump and duodenum. No end-result given.

Walzel:¹¹² Tube bridging gap of 4 cm. Well two and one-half years later.

Walzel: Tube bridging hepatic stump and duodenum. Eleven months later the tube, blocked and foul, was removed.

Walzel: Four months after treatment of stricture of choledochus with T tube, recurrence. Gap of 2 cm. was then bridged by long tube extending into duodenum. Recurrence seven months after was relieved by hepatoduodenostomy. Symptom free eight months later.

REPAIR OF DUCT OVER BURIED TUBE

Steindl: End-to-end suture over a rubber tube of common duct defect, 3 cm. in length, tube projecting not over one inch into the lumen of the duodenum. Excellent result. Time not stated.

Steindl: Sixteen months after instituting hepatic drainage in extensive stricture of the choledochus, tube passed from hepatic stump into duodenum and covered with contiguous tissue (Wilms-Sullivan operation). Recovery.

Steindl: Defects in the wall of both common duct and duodenum each $1\frac{1}{2}$ cm. in diameter were repaired over a rubber tube. The consequent constriction in the duodenum was relieved by a posterior gastro-enterostomy. Excellent result. Time not stated.

Whipple: After repair of common duct over a buried tube, patient lived for two years and then died from biliary cirrhosis with enlarged spleen.

STRICTURES OF THE BILE DUCTS

BILIARY FISTULA IMPLANTATION

Russell:⁸⁹ Biliary fistula of seven months' duration into the stomach. Well four and one-half years later.

St. John: Fistula with skin encircling orifice into stomach. Patient symptom free at end of three years, when lost track of.

Lilienthal: Biliary fistula with skin encircling orifice into stomach. Patient died four years later from cancer of stomach without sign of recurrence.

Williams: Fistula in patient aged four into duodenum without tube. Patient symptom free 23 years after operation.

Roeder: Fistula into duodenum. With the exception of occasional fat indigestion patient symptom free seven years, later.

Roeder: Biliary fistula into duodenum using a long catheter. This subsequently became disengaged and caused death by penetrating the pelvic sigmoid, three months after operation.

Masson: Fistula into duodenum. Death on fourth postoperative day from hemorrhage.

Judd: Fistula into stomach. Death on third day from shock.

Judd: Fistula into stomach; one and one-half years later, recurrence, relieved by hepatoduodenostomy with dilatation of the stricture.

Pemberton: Fistula into duodenum. Four months later contraction of the fistula. Duct reconstruction over a T tube.

Walters:¹⁰⁸ Fistula into duodenum. Well two years later.

Walters:¹⁰⁹ Fistula into stomach. Death fourth day after operation.

Walters:¹¹⁰ Fistula into duodenum. Well two and three-quarter years later.

Judd: Fistula into duodenum (?). For following two months intermittent jaundice. Death three years after operation.

Walters:¹⁰⁴ Fistula into duodenum. Well three and one-half years later.

Walters: Fistula into stomach. Death fourth day from hemorrhage and hepatic insufficiency.

Masson: Fistula into duodenum. Patient died nine years later from cerebral hemorrhage without sign of recurrence.

Walters:¹⁰⁰ Fistula into stomach. Four months later, contraction. Operation repeated followed by a second contraction nine months later. Patient died five months after the second operation.

Walters:¹⁰⁷ Fistula into stomach. Too recent for end-result.

Vincent: Fistula into duodenum. Intermittent attacks of cholangitis 14 months after operation; fistula had contracted to fibrous cord. It was dilated to 14 F. and again anastomosed to duodenum. Attacks of cholangitis continued and patient died three and one-half years after first operation from enlarged liver and spleen.

Lahey:⁶⁰ Fistula into stomach. For several months cholangitis. Then symptom free and well after 15 years.

Lahey: Fistula into duodenum. Periodic attacks of cholangitis. Liver greatly enlarged filling more than one-half of the abdomen.

Lahey: Fistula into stomach. Then cholangitis and a subdiaphragmatic abscess which was drained. At end of three years, when patient was lost sight of, condition was unsatisfactory.

Lahey: Fistula into stomach. Bedridden with cholangitis. No recent report.

Lahey: Fistula into stomach. No cholangitis. No recent report.

Lahey: Fistula into duodenum. Death three months from cancer of the pancreas.

Lahey: Fistula into duodenum. Death three months after operation.

Lahey: Fistula into duodenum. Death 13 days later from persistent hemorrhage.

Lahey: Death on fourth day after fistula into duodenum, subsequent to a previous gastrectomy.

Heidenhain: *Fistula into stomach. Contraction in three weeks, followed by tube reconstruction into duodenum. Cholangitis and death (probably) three years later.*

Tietze:¹⁸ *Fistula into jejunum. Death from abscess of the liver.*

Magnus: *Fistula into duodenum. Well two months later.*

Von Stubenrauch, Cahen, and Dobrotworsky have all experienced contraction of fistulae into stomach.

Whipple: *Implantation into duodenum. Operative death.*

Whipple: *Implantation into duodenum. Operative death.*

Whipple: *Implantation into duodenum. Operative death.*

Whipple: *Patient well 55 months after operation.*

Whipple: *Implantation into stomach followed by stenosis. One year later choledochoduodenostomy. End-result not stated.*

Pickhardt: *Implantation into duodenum. Patient gradually failed and died after several months.*

HEPATODUODENOSTOMY

Von Redwitz: *Symptom free two years after operation in which the tube passed through a Witzel opening in the duodenum, was brought out of the abdominal incision. (Posterior gastro-enterostomy.)*

Leriche: *Recurrence two months after duct reconstruction with buried tube (due possibly to the too early passage of the tube). Although nine months later there was an accumulation of bile over the hepatic dome, patient was symptom free for the following 21 months after the hepatoduodenostomy except for two mild attacks of cholangitis. The attacks then became more intense and patient died five years after the anastomosis.*

Moritz Cohn: *Hepatoduodenostomy with tube emerging through Witzel opening in the duodenum, and which was removed on the twelfth day. Well 12 years after operation.*

Melchior: *Death between one and two years after operation from liver abscess (see end-to-end anastomosis).*

Alessandri:¹ *Operation for extensive stricture. Tube was removed through an incision in the duodenum at the end of a year. Patient symptom free eight and one-half years after operation.*

Wallstein:¹¹⁸ *Operation over tube extending upward into both left and right hepatic ducts (tending to keep tube in place). Well three years later.*

Enderlen: *Hepatoduodenostomy owing to a complete obliteration of the orifice of a previous jejunoduodenostomy. Died eight days later.*

Bernhard:⁹ *Reports 13 cases with five operative deaths. One patient died four years after operation from septic cholangitis, three have occasional attacks of mild cholangitis and three are symptom free, 10, 11, and 24 years after operation.*

Erdmann, J. F.:²⁵ *Hepatoduodenostomy performed shortly after the evacuation of a large amount of bile from the abdomen. Symptom free 13 years after.*

Erdmann, J. F.:²⁶ *After failure of Wilms' operation, hepatoduodenostomy over tube, remaining in situ four months. Symptom free 17 years later.*

Erdmann: *Recurrence of symptoms of stricture due to the clogging of the tube over which the anastomosis was done five and one-half months after operation. Relieved by inserting a smaller tube. Final result not known.*

Erdmann: *Death from pneumonia one year after operation, in a condition of extreme jaundice.*

Erdmann: *Save for occasional mild attacks of cholangitis and pain, patient is symptom free 18 years after operation.*

Erdmann: *Recurrence, patient being subsequently operated upon by another surgeon.*
Verdi:¹⁰¹ *Ten months after an end-to-end anastomosis, hepatoduodenostomy for recurrence. Nine months later the calcified tube was removed through an incision in the duodenum. Since then symptom free, ten years after operation.*

Verdi: Recurrence eight months after hepatoduodenostomy, patient dying subsequently from pneumonia, unrelieved.

Hunt: Hepatoduodenostomy over a tube (passed five months later). Several mild attacks of cholangitis. Symptom free at end of five years. Recent roentgenograms show passage of air into the tributaries of the hepatic vein.

Fowler:¹² Recurrence after a few months due probably to the too early passage of the tube. Operation repeated by another surgeon with death three years after the first operation in jaundice.

Walters:¹⁶ Refers to 15 cases of either hepato- or choledochoduodenostomy without details. Of these, one was symptom free at the end of five years, two at the end of two years, and two at the end of one year.

Mayo, W. J.: One of the earliest operations performed (1904). Patient symptom free 15 years later.

Judd: Cholangitis four years after operation. Tube was removed six years after operation. Patient symptom free six years after operation.

Judd: Operation followed by recurrence of stricture in one year. Operation repeated over a smaller tube. Well one and one-half years after.

Judd: Operation followed in ten months by cholangitis. Death four years after operation from biliary cirrhosis.

Guerry: To avoid tension a gap of half an inch, at the anastomosis, was bridged by small rubber tube which was passed on the fourteenth day. Symptom free 19 years after operation.

Guerry: Patient symptom free five years after operation. Lost sight of.

Guerry: Well at present (70 years old), 12 years after operation.

Guerry: Symptom free eight years after operation.

Guerry: Symptom free six years after operation (now over 70).

Guerry: Symptom free three years after operation; lost sight of.

Guerry: Symptom free five years after operation.

Walzel: Reports seven cases, of which the first died after several operations from extensive yellow atrophy of the liver. This led him to devise a special technic (see original article) in the remaining six. Of these, two succumbed to operation, the remaining four being symptom free for various periods up to three years (1929). (Inquiry as to the present condition of these patients has failed to elicit any response.)

Whipple: Patient died 18 hours after operation.

Whipple: Patient symptom free 20 months after operation.

Whipple: Patient symptom free 56 months after operation.

Dreesman:²⁰ After failure of end-to-end anastomosis a hepatoduodenostomy, supplemented by posterior gastro-enterostomy with division of the pylorus, was performed. Recovery. No end-result mentioned.

END-TO-END ANASTOMOSIS

Von Redwitz: Suture of duct three days after it had been divided during cholecystectomy. Recurrence in less than a year and again after a second operation in ten months. Then hepatogastrostomy, the hepatic stump being sutured to the edge of a gastric defect, due to the pressure of the rubber tube, supplemented by a posterior gastro-enterostomy. Symptom free one year later.

Melchior: Stricture following an immediate suture of the divided duct during cholecystectomy, then hepatoduodenostomy. Death from abscess of the liver between one and two years later.

Braeünig:¹¹⁰ Suture of duct divided during cholecystectomy with tube extending through the duodenal wall (Witzel). Complete biliary fistula. Three months later suture of fistula to the divided end of excluded jejunal loop.

Tietze:¹⁸ Subsequent stenosis and death, in another hospital, after end-to-end suture over a T tube for stricture.

Papin:⁸⁴ Suture of partially divided duct during cholecystectomy without a tube. Symptom free ten years later.

Fiolla: Symptom free for two years after suture of divided duct ends. Death from violent septic cholangitis.

Downes:⁴⁰ End-to-end suture of duct divided during cholecystectomy. Death from cancer of the prostate 16 years later.

Downes: Division of stricture subsequent to cholecystectomy one-eighth of an inch long with T tube for a month. Operation repeated for recurrence two months later. Subsequent cholangitis for two or three years, gradually decreasing. Since then mild occasional bilious attacks from indiscretions in diet. Otherwise symptom free 13 years after operation.

Downes: Well for 28 months after suture of duct divided during cholecystectomy. Then cholangitis followed by drainage with a T tube for seven months. Death one year later from mesenteric thrombosis and cirrhosis.

Douglas:¹⁸ Suture over a T tube for stricture between 1 and 2 cm. in length. During the following year attacks of cholangitis. Then symptom free. Well 11 years later.

Douglas: End-to-end suture for stricture following division of the hepatic duct near cystic duct during cholecystectomy. Cholangitis attacks during the second year after. At end of 14 years symptom free.

Matthews:⁶⁵ End-to-end suture for stricture, months after a cholecystectomy, over tube emerging through an opening lower down in the duct. Well 14 years.

Matthews: End-to-end suture of the hepatic duct divided during cholecystectomy, a catheter being inserted down through the stump of the cystic duct. Early removal of the tube. Some cholangitis for a year. Well four years.

Nordmann:⁶⁰ Immediate suture of divided duct. Recurrence of stricture, then hepatostomy.

McArthur:⁷⁵ Suture over tube with "reversed cuff" extremity after excision of stricture following cholecystectomy. Tube passed on sixty-third day. Death from cancer of the stomach two years later.

McArthur: Suture after excision of stricture over "cuffed" tube which never passed. Death from cholangitis 18 months later.

McArthur:⁷⁶ Recurrence four years after suture for stricture. Then choledochoduodenostomy over tube which passed on twenty-seventh day. Occasional attacks of cholangitis. Patient well six years later.

McArthur: Suture of duct over "cuffed" tube which passed nine weeks later. Recurrence. Operation by Doctor Finney, patient dying one year later in jaundice.

McArthur: Suture of duct over "cuffed" tube. Well five years later.

Seward Erdman:²⁷ Immediate suture of duct divided during cholecystectomy over tube which became clogged three months later. Smaller tube inserted. Nine months after operation cholangitis, repeated since with decreasing frequency. In good condition three years after operation.

Bartlett, W:⁴³ Suture over a T tube for stricture in common duct. Tube in place one year. Symptom free at end of six years.

Schweizer:⁹⁴ Suture of duct ends over a T tube which remained in place for 18 months. Symptom free at end of 14 years.

Riggs:⁸⁹ End-to-end suture for gap of 3 cm. after removal of cicatricial tissue. Death from myocarditis 14 years later, without recurrence.

Stetten:⁹⁵ End-to-end suture of hepatic duct. Thirteen years later mild attack of cholangitis due probably to a cardiac condition, from which patient died without evidence of recurrence 19 years after operation.

Homans:⁴⁷ End-to-end suture of duct completely torn across during cholecystectomy. Symptom free at end of ten years.

Homans: Division of common duct with nicking of the hepatic duct during chole-

cystectomy. Immediate suture. Gallbladder left in situ. Symptom free ten years after operation.

Walters:¹⁰⁸ Four cases of end-to-end suture after excision of stricture. Two well one year after operation, the others for shorter periods.

Horgan:⁴⁹ End-to-end with L shaped tube, the extremity of which was brought out through a separate incision in the wall of the duct. Symptom free seven years.

Horgan: Sutured after excision of a stricture in the hepatic over L shaped tube brought out through a separate incision in the wall of the duct. Symptom free at end of eight years.

Horgan: Suture of choledochus torn across in the delivery of a stone during choledochotomy, over L shaped tube brought out through separate incision in the wall of the duct. Symptom free at end of ten years.

Judd:⁵⁴ End-to-end over T tube after excision of stricture. Well five years later.

Judd: End-to-end followed by abscess of the liver. Drainage. Subsequent choledochoduodenostomy.

Judd: Fifth recurrence within a year after end-to-end suture. Reconstruction of duct. Well two years after.

Judd: End-to-end suture over T tube. Well seven and one-half years later.

Judd: Gap resulting after excision of stricture in hepatic duct filled by interposition of the cystic stump. Well seven years later.

Balfour:⁴ End-to-end anastomosis of hepatic duct divided during cholecystectomy. Patient well five years later.

Eliot:²² End-to-end suture months after cholecystectomy for stricture in common duct. Death 18 years later from intercurrent disease.

Eliot:²³ End-to-end suture of hepatic duct months after cholecystectomy. Several attacks of cholangitis following operation. Symptom free ten years after.

Walzel:¹¹⁷ Divided ends of choledochus sutured over a long tube into duodenum. Well two and one-half years later.

CHOLEDOCHODUODENOSTOMY

Downes:¹⁰ Four weeks after hepatic drainage, choledochoduodenostomy over a 14 F. catheter. Nine months later recurrence. Dilatation of stricture through duodenal approach up to 18 F. with insertion of tube. During following year attacks of cholangitis of increasing frequency and severity with death six years after the first operation and five years after the dilatation.

Von Redwitz:¹⁰⁰ Choledochoduodenostomy three weeks after cholecystectomy for stricture of common duct. Three years later hepatoduodenostomy over tube introduced after the Witzel method into the duodenum, with posterior gastrostomy. The previous anastomosis was obliterated.

Sasse:^m Choledochoduodenostomy for stricture, the duct containing purulent material. Successive attacks of first mild and later severe cholangitis until the death of the patient six years later. Autopsy showed calculi in the duct, a lumbricoid, abscess of the liver and basilar pneumococcus meningitis.

Behrend:⁵ On the twenty-first day after a choledochoduodenostomy for stricture, a T tube was inserted into the duct because of jaundice, draining bile and duodenal contents. Symptom free 19 years afterward. Behrend refers to "several similar cases since, all symptom free."

Williams: Choledochoduodenostomy for acholic stools. Symptom free three years later.

Brooks:¹¹ Choledochoduodenostomy (blind end of duct). Well one and one-half years afterward.

Lewis:¹²⁰ Two cases of choledochoduodenostomy (blind end of duct). Too recent for end-result. Postoperative cholangitis in one case.

Peterman:⁸⁵ Choledochoduodenostomy for stricture at the ampulla (possibly inflammatory). Well 12 years later.

Judd:⁵⁴ Choledochoduodenostomy following failure of end-to-end anastomosis over a tube, which was vomited up a year later. In following year abscess of liver, successfully drained. Then well three years later.

Walters:¹¹⁰ Choledochoduodenostomy for stricture 1½ cm. long. Symptom free after two years.

Fensterer: Choledochoduodenostomy for stricture over a rubber tube. Patient died six years later from cancer of the cecum. Autopsy showed a patent choledochus with complete obliteration of the anastomosis.

Guerry:⁴¹ Choledochoduodenostomy. Death from ascending infection four years after operation.

Guerry: Two cases dying from shock and pneumonia, shortly after operation.

Guerry: Choledochoduodenostomy. Symptom free six years later.

Guerry: Choledochoduodenostomy for duct injured during choledochotomy. Symptom free one year later.

Cave:²⁴ Choledochoduodenostomy with Murphy button for stricture in common duct. Patient symptom free nine years later.

Whipple: Choledochoduodenostomy. Death from peritonitis four days later, due to tearing of suture line.

Whipple: Choledochoduodenostomy. Death on sixth day after operation from periduodenal hemorrhage causing obstruction.

Whipple: Choledochoduodenostomy. Symptom free two years later.

Whipple: Choledochoduodenostomy. Well for 30 months, then one attack of jaundice with death three months later. Death reported as carcinoma, not proved by autopsy.

Fründ, H.:³¹ Rubber tube inserted through papilla (transduodenal) up into and through stricture of common duct. During following two years, cholangitis. Then duct found widely dilated above stiffened and incrustated tube. Choledochoduodenostomy tube being removed. Symptom free nine years later (aged 61).

Kaspar: Reports six cases of cicatricial stricture of which four were associated with calculus in the common duct. Those without calculus had followed a previous cholecystectomy. Of 38 cases of choledochoduodenostomy for various conditions, only one patient died (cancer of pancreas; pneumonia). Like Sasse and Flörcken, Kaspar is an enthusiastic advocate of this operation and thinks it is vastly superior to Kehr's external drainage. Of 99 cases (Jurasz, Toole, Sasse, Flörcken, Peterman, Moll, Lowenstein, von Haberer, and Kaspar) operated upon for various conditions, only six deaths occurred. In only three instances was opportunity afforded to subsequently examine the site of anastomosis. In Toole's case (nine months after operation), and in Jurasz' case (13 months after operation), the anastomotic orifice was patent. In Sasse's case (six years after operation), the orifice was completely closed. Kaspar cites the following advantages over Kehr's external drainage: Prevention of loss of bile, no pressure ulceration, no angulation of tube, no persistence of the fistulae.

CHOLECYSTOGASTROSTOMY

R. T. Miller, Jr.:⁷³ For stricture common duct (no previous operation). Well one year later.

CHOLECYSTODUODENOSTOMY

Anschütz:² For stricture choledochus. Well 11 years later.

Whipple: For stricture in the common duct, following trauma, gallbladder and cystic duct being normal. Patient symptom free 70 months later.

Walters:¹⁰⁹ Cholecystoduodenostomy. Good result. Symptom free three years later. Barium seen to enter gallbladder.

Judd:⁵⁴ Cholecystoduodenostomy after two previous operations for biliary fistula, fol-

lowed in three months by cholangitis. Subsequent reoperation disclosed stricture of the common duct for which hepatoduodenostomy was performed over a rubber tube, the stricture being excised. Cholangitis developed ten months later and the patient ultimately died of biliary cirrhosis four years after the last operation.

Wolff:¹¹⁷ Reports a case of anastomosis between gallbladder and choledochus. Well four years later.

CHOLEDOCHOCHOLECYSTODUODENOSTOMY

Whipple: Between a stricture following cholecystectomy (?) and the duodenum, a cavity resembling the gallbladder, and filled with bile, was interposed. This communicated with the dilated duct above the stricture. It was probably a newly formed adventitious space in the situation of the previously removed gallbladder. The utilization of a portion of its wall in forming the anastomosis accounts for the name of this unusual operation.

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DISCUSSION.—DR. FRANK H. LAHEY (Boston, Mass.).—Everyone who has been interested in strictures of the common and hepatic ducts owes Doctor Eliot a debt of gratitude. His original contributions in which the work done on anastomoses for strictures of the common duct, going over the literature up to approximately 1922, 1923, and 1924, as I recall it, covered all of the foreign and English speaking literature in the world, and is an extremely valuable article for anyone to read who is interested in this subject.

There is little to be added to what he has said except my own personal and practical experience with this subject. We have now operated upon 20 strictures of the common duct, and it is but fair to say that they have all been sent to us and are not cases we have produced ourselves.

One deals with three types of stricture. One is the hopeless type, in which an infection produces a fibrosis of the entire main biliary duct. This type we have found entirely hopeless, since this fibrosis extends up into the intra-hepatic portion of the duct. A very hopeful type is one which occurred in a case we have just sent home, *i.e.*, with the stricture at the lower end of the common duct. I would call attention to the fact that these cases usually occur after cholecystectomies, that there is a dilation of the stump of cystic duct which can be implanted into the duodenum very satisfactorily. I believe in this type of stricture that this is more satisfactory than the lateral anastomosis between the dilated duct and the duodenum. The use of a small tube in the dilated cystic duct which can be implanted and sutured into the duodenum makes it a very satisfactory procedure.

Strictures of the hepatic duct in the majority of instances follow technical difficulties with the cystic artery. They are the result of excitement, I think.

The cystic artery gets loose, bleeds into the deep operative field. The inexperienced operator fails to realize that by pinching the hepatic artery with his finger he can stop the bleeding artery, wipe the field dry, find the bleeding vessel and control it accurately. Instead of this, he clamps wildly and picks up the hepatic duct in the clamp, thus causing the stricture. These are difficult types of stricture and I believe it requires the nicest judgment to determine whether one would perform a direct anastomosis of the duct or a reconstruction of it. We have in some of the cases, effected a Mikulicz type of reconstruction on the strictured ducts, only to have most of them become strictured again, and in some of these cases, I am sure it would have been better had we cut the strictured duct off and performed a direct anastomosis between the end of the duct and the duodenum. The most satisfactory operation in strictures of the hepatic duct will be the direct anastomosis between the end of the duct and the duodenum as suggested by Dr. William J. Mayo. I think the implantation of the external biliary fistulae will result in failure in most of the cases. We have performed 14, and only two have been permanently relieved, due to the fact, I think, that the fistulae in most cases contract and reobstruct.

There are some things which I think of practical value in connection with the implantation of the fistulae if one has no other recourse. If one has such a high stricture that it is close to the division of the hepatic duct, then there is nothing left to do but to implant the fistula. From our experience, I believe it is best to implant it into jejunum. If it is implanted in the stomach, it can easily be pulled out following vomiting and the vigorous gastric contractions associated with it. Furthermore, if implanted in the stomach, it will be pulled over toward the midline, thus making considerable traction on the fistula, and predisposing to necrosis of it and allowing it to be pulled away from its bed in the liver.

On the other hand, a jejunal loop can be brought up to the portion of the fistula which is attached to the liver and an implantation effected. The jejunum can then be sutured to the capsule of the liver so that there is no strain, upon the fistulous tract itself. These measures will, in our experience, produce better results in the implantation of fistulae but as already stated, the operation is in itself, of necessity, a poor one and a makeshift.

I think as to the treatment of strictures of the bile duct, we have accomplished more today, in voting in favor of certification of surgeons, than has been accomplished up to date by any of the proposed technical measures.

DR. ALLEN O. WHIPPLE (New York, N. Y.).—Almost all of the studies that have been made in the problem of bile duct reconstruction, as brought out so ably in Doctor Eliot's paper, carry through them the constantly recurring and sinister motif of cholangitis. The prevention of this duct and liver infection seems to me to be one of the most difficult problems that we are faced with in the care of patients with duct reconstruction, where the reconstruction has to be done in order to save the patient from the misery and ultimate outcome resulting from complete stenosis.

As has been brought out by Doctor Eliot and Doctor Ivy in the discussion, the maintenance of the sphincter mechanism is the underlying reason for the success of the end-to-end anastomosis of the two cut ends of the duct. It is the lack of such a mechanism that is one of the real difficulties in the operation reported by us a year ago for radical removal of a part of the duodenum and pancreas for carcinoma of the papilla of Vater. In the paper read by Doctor Parsons last June he brought out the fact that in one of our cases the cholangitis was the cause of death seven months after the operation, as a result

of multiple abscesses of the liver following cholangitis. Since that time we have carried out the procedure in two other cases successfully; in one patient there have been transitory attacks of cholangitis, but the patient is still living, 18 months after the operation.

If some means could be devised to avoid the occurrence of cholangitis, I would be very much more enthusiastic about our procedure as a method of dealing with carcinoma of the papilla, but I wish to sound a note of warning in regard to the danger of cholangitis where the gallbladder is anastomosed directly to the stomach, into which jejunal contents are emptying.

DR. WALTMAN WALTERS (Rochester, Minn.).—In 1931,¹ I presented a group of 30 cases in whom resection of the common and hepatic bile ducts and ampulla of Vater had been performed by me at the Mayo Clinic. Since that time I have operated upon an additional 17 patients, making a total of 47. I had hoped to summarize all of these cases to date, but am sorry that circumstances have prevented the completion of this review, so it will have to be presented in detail at a later time. For the purposes of this discussion, I shall confine myself to a few general comments on the results we have obtained.

When there was sufficient duct above the stricture to enable one to anastomose it to an opening made in the duodenum, choledochoduodenostomy or hepaticoduodenostomy, this has been the preferable procedure, and it has been performed in 24 of the cases, in 11 during the period from 1932 to 1936.

Time permits only the briefest reference to the results in this series of 47 cases. Generally speaking, I have had no reason to change the opinions which I expressed in the conclusions published in 1933,¹ namely, that very good results have been obtained in many cases in which accurate anastomosis has been made between a remaining portion of the duct and an opening made in the duodenum. Failure to obtain lasting good results could almost be predicted at the time of anastomosis if the stump of the duct was too short to permit accurate mucous membrane-to-mucous membrane anastomosis to the opening in the duodenum, and in those cases in which it was evident that marked cirrhosis or intrahepatic infection was present, which was characterized by purulent bile or granular stones within the hepatic ducts. For example, in Cases 1 and 2 of the 1933¹ report, the patients are living and well without having had a return of evidences of biliary obstruction. In the first case ten years have elapsed since operation, and in the second, eight years. In both instances there was sufficient duct above the stricture so that an accurate anastomosis could be made between it and an opening made in the duodenum.

I formerly held the opinion that excision of a localized stricture of the common and hepatic ducts, in which anastomosis was made between the ends of the duct after the excision, was likely to be followed by recurrence of the stricture at the point of the anastomosis. However, contrary to this was the case (Case 18 of the 1933¹ series) in which I excised a neurofibroma that was obstructing the common duct at the bifurcation of the hepatic ducts. The two ends of the hepatic ducts were sutured to the end of the common duct. The present condition of this patient was recently reported by Comfort and myself.² Whereas she had occasional biliary colics the first year or two subsequent to operation, in the last four years she has been free of biliary colic and jaundice. In another instance (Case 16) local excision of a stricture of the common duct located directly beneath the liver has been followed by results which persistently remained good after a five year period.

Transplantation of external biliary fistulae, established because of complete

absence of an extrahepatic duct, continues to be a useful procedure. One of the patients who underwent this procedure in December, 1929 (Case 23), continues to be well and is without evidences of biliary colic or obstruction. That case was one of four in which I transplanted external biliary fistulae. I used the procedure in two other cases, in one recently in which, at the time the external biliary fistula was established, the patient was very deeply jaundiced and had a serum bilirubin of 13.5 mg. per 100 cc. In this case the patient had such a hemorrhagic tendency that in addition to subcutaneous hemorrhages, she also had subconjunctival, intestinal and uterine bleeding; the coagulation time was elevated to 16 minutes. After a prolonged period of preliminary preparation, consisting of the intravenous glucose, blood transfusions, and the administration of calcium, an external biliary fistula was established. The serum bilirubin rapidly decreased to 5.8 mg. per 100 cc. On March 27, 1936, I coned out and transplanted the fistula into the stomach. The incision healed promptly and she was allowed to return home April 24, 1936, with a serum bilirubin of 2.8 mg. per 100 cc.

SUMMARY.—Sufficient data are available in a group of 47 cases of stricture of the common duct, that were operated on by me at the Mayo Clinic, to show that plastic operations for stricture of the common and hepatic ducts are justified, not only from the standpoint of relief of obstructive jaundice, but prolongation of life.

When sufficient duct remains above the stricture so that an accurate mucous membrane anastomosis can be made to the duodenum, good results may be expected, providing there is not too much infection within the liver or in the wall of the stump of the duct used to make the anastomosis. Many such instances of this type have been reported in which the patients continue to remain well and free of symptoms for years subsequent to operation.

Local excision of a stricture or tumor of the duct has been followed in some instances by persistently good results over a period of years. The operation of the establishment of an external biliary fistula and its transplantation into the stomach or duodenum continues to afford hope to patients with complete stricture of the extrahepatic ducts for whom no other type of anastomosis is possible.

If I may comment on Doctor Ivy's interesting presentation, I should like to say that clinical observations carried out at the Mayo Foundation have demonstrated the presence clinically of this sphincter mechanism at the lower end of the common duct.

It consists of an operation upon the common duct, in which, when the patient has pain, it can be controlled by as small a dose as one-sixth of a grain of morphine, there occurring an increase in pain from the use of water. When the pain is experienced, the pressure can be recorded, and interestingly enough, when one-hundredth of a grain of nitroglycerin is given under the tongue, the pain subsides. Studying it further, they have used, in the common duct, an opaque substance, brominol, and administering morphine, in those patients who have pain after a cholecystectomy and who have had also an exploration of the common duct, and they have found that when the pressure within the duct increases one can see the sphincter contract and the intra- and extrahepatic ducts fill with this opaque media. Amyl nitrite inhaled will give immediate relief not only of the pain but also of the intrahepatic duct pressure. These procedures have been employed in several patients who have continued to have colic subsequent to operations on the gallbladder, with immediate relief of pain.

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DR. ROSCOE R. GRAHAM (Toronto, Ont.).—Doctor Eliot's work has stimulated us all, and given us great help. We have had two cases from which we have learned lessons, which I would like to present to you. In the first case I was responsible for the subsequent complications. The patient was operated upon through a transverse incision. A very simple operation was rendered difficult because of the angle of approach. However, it was accomplished, apparently satisfactorily. We still belong to the group of surgeons

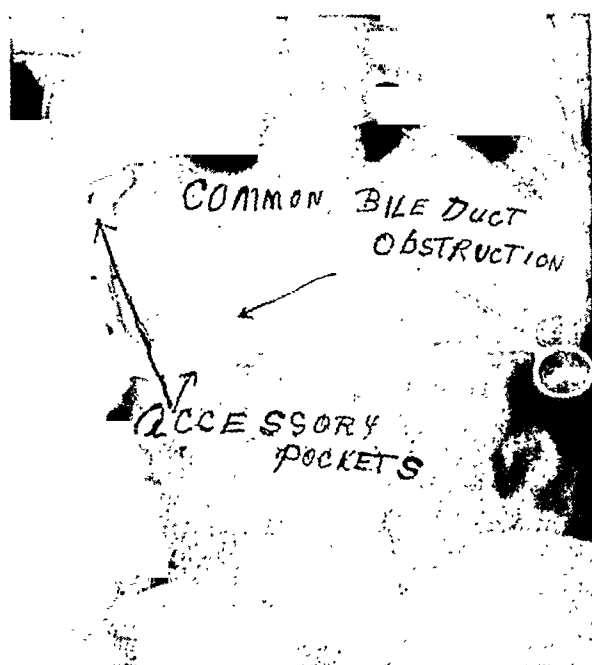


FIG. 1.—Injection of the sinus, showing the puddling of bile about the biliary ducts.

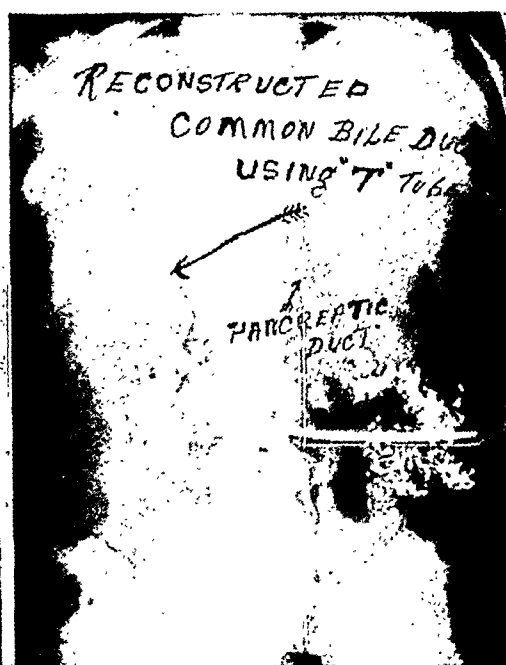


FIG. 2.—Showing the restoration of continuity of the biliary ducts and outlining the pancreatic duct.

who leave a drain in following the removal of the gallbladder, which is taken out on the third or fourth day. This was done in this case. Convalescence was uneventful for 48 hours. Then she began to complain of abdominal pain, had violent chills, and developed a mild jaundice accompanied by severe pain in the right shoulder: no drainage from the tube. Removal of the tube and investigation of the wound at the end of another 24 hours resulted in the evacuation of a large amount of bile. This temporarily relieved the situation, and she was allowed to return home. Shortly afterwards, however, there was a recurrence of pain, chills and fever, and she was admitted to hospital, intensely jaundiced, with frequent severe chills. Injection of the sinus (Fig. 1) showed accessory pockets and a puddling of the retained bile along the lateral margin of the liver, and a stricture of the common bile duct.

This gave us much food for thought, because I believe we were in error, and responsible for this situation, for two reasons: First: our approach was inadequate; second: our drainage was inadequate. We have since abandoned the transverse incision, but we still use drainage. However, the drainage tube

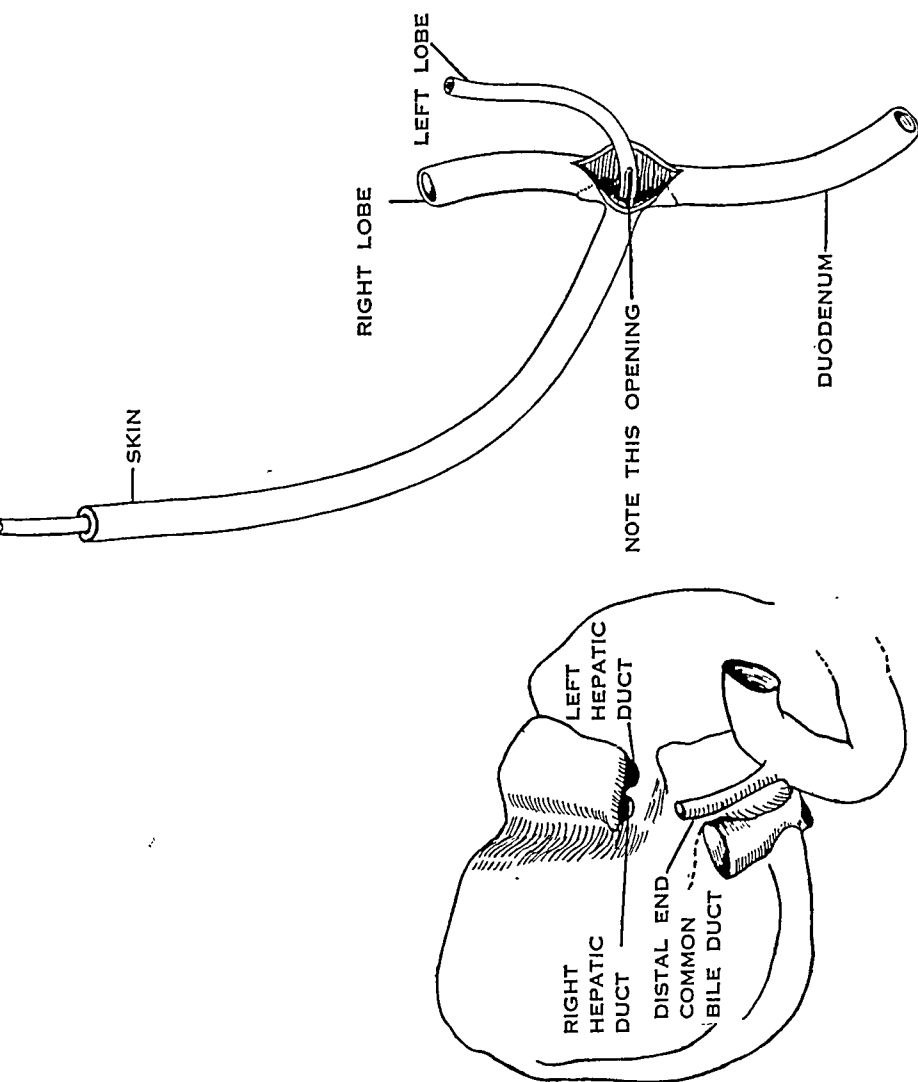


FIG. 3.—Showing the right and left hepatic ducts and the lower end of the common duct.

FIG. 4.—Showing the modification of the T tube to meet this problem.

FIG. 5.—Showing the method by which the modified tube was placed in the ducts.

which is inserted has a segment of the circumference excised throughout its entire length, so that if we have the misfortune to have a leak from the cystic duct stump, it will find its way out along this channel before producing, as in this case, stenosis of the duct, the result of periductal edema from retained bile.

Figure 2 shows the outline of the biliary ducts and the pancreatic duct following the injection of lipiodol postoperatively. Her operation was completed March 21, 1934, and the patient, whom I have seen recently, is at the present time perfectly well, with no return of pain.

We were in a quandary following the taking of this picture as to the length of time that the T tube should be left in position. We have had, in the past, unhappy experiences following the too early removal of the T tube, due to a recurrence of the stenosis. Our problem in this particular case was solved for us, because, due to an accident, the tube was dislodged at the end of 15 months.

The second case, which I had the opportunity of seeing and operating upon with Dr. Harold J. Couch, presented a difficult problem. Six months previously she had her gallbladder removed. She remained well for about four months, when she began to have a return of colic, accompanied by chills and fever. Investigation led to the diagnosis of stenosis of the common bile duct.

At operation the situation as represented in Figure 3 was found, namely, two holes in the liver, which we were able to identify as the lower end of the right and left hepatic ducts, and a gap of about three-quarters of an inch between that and the isolated lower segment of the common duct.

To meet this situation we modified the T tube as shown in Figure 4, by passing a smaller tube through the long end of the T tube, bringing it out in the middle of the T. At this point it is important to have an opening cut in the smaller tube so that bile can find its way into the lumen of the second tube. The tube was placed, a limb in each right and left hepatic duct, and the third in the common duct, as indicated in Figure 5. Then, by mobilization of the duodenum, it was possible to approximate the common duct to the ends of the hepatic ducts. This operation was completed in July, 1933. The tube was removed at the end of six months, after injection of the ducts with lipiodol demonstrated their patency. This patient is, at the present time, well, and has had no recurrence of her symptoms.

DR. J. SHELTON HORSLEY (Richmond, Va.).—We are all very much indebted to Doctor Eliot for his splendid work on surgery of the common duct, not only as given in this paper but in previous communications.

A good many years ago I attempted experimentally to reconstruct the common duct and used a segment of vein. The use of a vein was not original with me; I do not know where I got the idea, but I worked out a rather complicated technic. Most of the dogs died, but those that recovered I kept, and after a few months they all developed jaundice and died or were killed. I think the one that lived longest lived eight or nine months. The postmortem on that dog, as well as on the others, showed that the segment of transplanted vein (which was inverted and looked like ideal tissue from a mechanical standpoint, thin, and easily nourished) was invariably infiltrated with leukocytes, eventually contracted and formed a complete stricture.

In other words, in reconstructing the common duct, it is necessary to know biology. Tissue that is transplanted must be more or less accustomed to the environment, and to the secretions. The vein was unaccustomed to, and irritated by, bile, and deep leukocytic infiltration was followed by stricture.

If there can be a direct anastomosis of the duct, that is very good, but if that cannot be accomplished, anastomosis to the duodenum is the second best choice.

We also have to remember that hepatitis is a thing that is more frequent than we suspect. The work of Evarts Graham many years ago showed it as a very common occurrence with even a slight inflammation of the gallbladder.

The happy results that Doctor Eliot has found in anastomosis of the common duct to the duodenum have not been entirely my experience. I recall one case in which it was necessary to do that because the gallbladder had previously been removed. I did a lateral anastomosis between the common duct and the duodenum. The patient made a fairly satisfactory immediate recovery, had more symptoms a few months later, and on roentgenologic examination with barium meal, an almost perfect pattern of the common and hepatic ducts could be seen. I wanted to disconnect the anastomosis, but he would not let me do it and he died a few months later with liver symptoms. Possibly an end-to-side union would have been better.

We owe much of the improvement in modern surgery, especially in the gastro-enteric tract, to the physiologist. It has been through disregarding many of the principles laid down by the physiologist, that we have gotten into trouble. Almost any anastomosis between the gallbladder and the common duct that is followed by hepatitis puts us in a hole, but it is often a condition, not a theory, that confronts us. We do not want to do it, but we have a patient who is certainly going to die unless we give some relief by drainage, and may die if we do. Anastomosis of the gallbladder to the duodenum would seem from a physiologic standpoint to be the most satisfactory of any of these operations, but even that undoubtedly is sometimes followed by unfortunate results. I think, however, that hepatitis in man seems to be better tolerated and does not have quite such an inevitable and unfortunate result as in a dog. Of course I cannot prove that, but I know some cases seem to continue for a long time with hepatitis, living pretty comfortably. We have so little idea of the actual functioning of the diseased liver, and the tests are so unsatisfactory, that not infrequently we have to make use of these procedures, even though they may be undesirable from a physiologic standpoint.

DR. JOHN DOUGLAS (New York, N. Y.).—Just ten years ago I read a paper on stricture of the bile duct, before this society, and reported 12 cases. At that time, the follow-up would seem to indicate that the results with anastomosis between the ends of the duct when possible were the most favorable. Two of these cases of my own were cases in which anastomosis had been made between the divided ends of the common duct, in one instance of the common duct itself, and in the other the junction of the hepatic and common ducts. I have been able to follow up both of those cases in the last few months, at Doctor Eliot's request, and both were still well, one 11 and the other 14 years after operation.

A point which is of considerable interest to me in those cases is that two or three years after the operation both patients had decreasing attacks of cholangitis. They had jaundice, chills, and rises of temperature. Doctor Ivy has told us that this is more apt to occur in the case where the sphincter of Oddie has been destroyed. Probably this is so, but both of these patients still had their sphincter of Oddie, and they both had jaundice with temperature.

We know that in cases of stricture of the common duct where there is jaundice, and in many cases where there are stones in the common duct, sometimes we will find a lot of muddy material in the common duct and sometimes almost cast like material, such as Doctor Ivy has spoken of.

Doctor Whipple has said if we could only find some way to prevent this cholangitis he would have more confidence in the possibility of these various operations. I do not know any way to prevent the cholangitis. However, these cases of mine seemed to get over the attacks more rapidly when given bile salts. There is still a question, of course, as to the effects on the flow of bile, but the presence of bile salts in bile, as is known, will keep the cholesterol in better solution, and the absence of bile salts will encourage its precipitation. It is a simple thing, but it seems in those two cases which I have followed over 10 and 14 years, respectively, when they got the bile salts they recovered from the attacks of cholangitis more rapidly than when they did not receive it; and whereas they got the attacks of cholangitis over two or three years or more, within the last two years something has happened which is now preventing their attacks of cholangitis.

DR. ELLSWORTH ELIOT, JR. (New York), closing: I have mentioned the administration of bile salts as a prophylactic postoperative measure for subsequent attacks of cholangitis. There are, in addition, two other forms of treatment mentioned for this purpose: (1) the injection into the duodenum of a solution of magnesium sulphate, and (2) the administration of secretin. Irrespective of the type of suture or anastomosis, the postoperative attacks of cholangitis are usually transitory, although, exceptionally, they may terminate in an ascending infection with invasion of the liver parenchyma.

The T tube has enjoyed great vogue, but Horgan, of Washington, has substituted an L shaped tube which may be readily withdrawn when desired without danger of rupture of the line of suture of the duct itself. Selim McArthur has also devised a substitute for the T tube quite similar to the L shaped tube but differing from it by being supplemented by the introduction of a second smaller tube which passes downward into the duodenum and through which medication may be introduced. Both of these varieties of duct drainage would seem to diminish the probability of rupture of the line of suture and subsequent recurrence of stricture.

Brandt, in 1912, reported five cases operated upon by Wilms in which the immediate result was highly satisfactory (duct reconstruction with buried tube). In two cases, 18 months, and in the others, a much shorter period has elapsed since he published his observations. Through the kindness of Professor Kerschner of Heidelberg, I am able to report that four of these patients died, two, two, 11 and 17 years, respectively, after operation, the first mentioned of gallstone disease. The cause of death of the next three could not be ascertained, while the fifth patient could not be traced. The unfortunate outcome of these cases may account in part for the unpopularity of the Wilms operation abroad.

Other surgeons besides Doctor Lahey have used the Mikulicz procedure, namely, widening the duct at the point of repair. I am under the impression that this procedure was used in several instances by the late Doctor Judd of Rochester and was followed by a recurrence of the stricture.

Regarding Doctor Horsley's remarks, I am told by Dr. Dean Lewis that experimental substitution of the wall of a vein or other fascial structure for the excised segment of a duct terminated in failure. Furthermore, plastic operations in which portions of adjacent hollow viscera were utilized for a similar purpose were generally unsuccessful and have been discontinued.

Failure of the bile to properly drain after cholecystectomy, to which Doctor Graham has referred, occasionally occurs. Two instances observed by colleagues in which such an accumulation occurred in the lesser peritoneal cavity, resulted fatally. Doctor Lahey, recognizing the possibility of such an

unfortunate postoperative complication, regularly introduces a suitable drain through the foramen of Winslow.

The retention of the drainage tube is, at times, difficult to control. In operations for stricture of the hepatic duct, retention is favored by the intro-



FIG. 1



FIG. 2

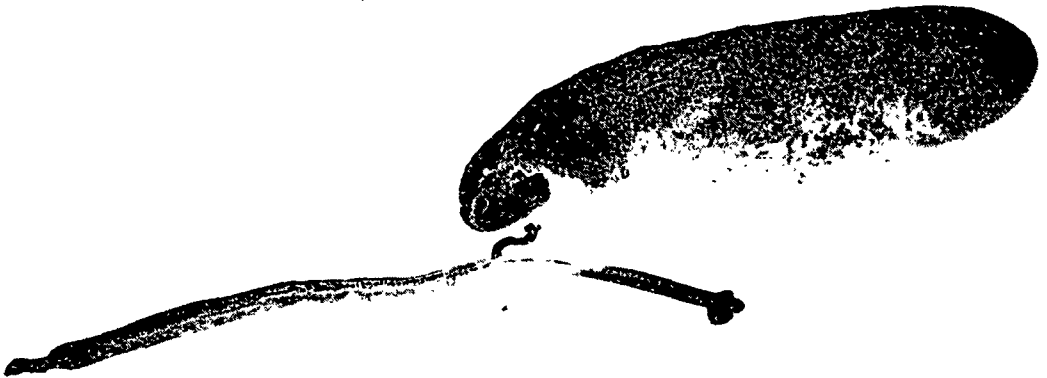


FIG. 3

FIGS. 1, 2 and 3.—Paraffin casts of gallbladders, cystic and common ducts showing variations in the caliber of corresponding parts.

duction of a Y shaped tube into the right and left hepatic ducts, the vertical part of the Y extending into the duct below. Furthermore, a number of operations have been performed, especially abroad, in which retention of the

tube has been insured by bringing it out through a Witzel opening in the wall of the duodenum or stomach into which the tube has been introduced, which emerges with the drain into the dressings, where it is firmly secured to the abdominal wall. Its withdrawal at any time, according to the judgment of the surgeon, can be effected without disturbing the repair of the duct wall.

In the Hildebrandt operation, the jejunum is divided a little below the jejuno duodenal junction, and intestinal continuity is reestablished by lateral anastomosis of the oral jejunal orifice about 10 cm. below the point of division. The distal jejunal orifice is then brought out of the abdominal incision and inserted through a tunnel behind the rectus sheath to the orifice of the biliary fistula with which it is anastomosed. This operation has been performed three times. In one case, the patient was alive and well ten years after the procedure; in the second, death occurred from ascending aseptic cholangitis, and in the third, it was a failure, another operation being subsequently performed. A modification of this procedure has been adopted by Dobrotworsky of Leningrad. The chief difference is that no anastomosis is attempted, but in its place the biliary fistula and the distal orifice of the jejunum are connected by a glass tube which can be removed, cleaned and reinserted at will. Through the glass tube in situ, the bile can be seen passing into the intestine. Several instances of this operation are reported by the author, one patient being alive and well 12 years later.

I have always thought it possible that the caliber of the normal hepatic and common ducts might not be uniform and might be subject to variations in different portions. With the cooperation of Doctor Helfrick, intern in the Knickerbocker Hospital, cadavers of adults, who had died violent deaths, were selected for investigation. After ligation of the hepatic ducts above and at the ampulla below, the gallbladder and cystic duct were injected with paraffin. After this had hardened, the enveloping soft tissues were dissolved by hydrochloric acid which left a cast of the interior of the biliary ducts and gallbladder. Each specimen treated in this way showed variations in the caliber of the duct. The caliber of corresponding parts of the duct showed considerable variations. These variations were most pronounced in the specimens in which the gallbladders were still attached (Figs. 1, 2, and 3).

It is not inconceivable that such variations in the normal ducts, especially at the junction of the cystic and hepatic ducts and at the ampulla, may predispose to the development of stricture in the presence of a calculus cholangitis.

CHOLECYSTODUODENOSTOMY COMBINED WITH PYLORIC EXCLUSION

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THE increasing number of papers dealing with operations for the anastomosis of the biliary passages with the digestive tract indicates the great interest which this subject attracts from the clinical and the experimental surgeon. For comprehensive surveys of the literature in this field, the reader is referred to the papers of Gentile,⁷ in English, Berard and Mallet-Guy,² in French, and Bernhard³ and Hutter,⁹ in German.

In animal experiments, a dilatation of the bile ducts and an ascending infection leading to hepatitis and cirrhosis almost invariably follow anastomosis of the bile ducts with the gastro-intestinal tract. The prominence of the hepatic lesions depends to some extent upon the site of the anastomosis, being least severe in the presence of cholecystogastrostomy and cholecystoduodenostomy and increasing in degree as the communication is made lower in the intestinal canal.

Clinical findings, on the other hand, have not been uniform. Most surgeons have considered that, in man, an ascending infection of the biliary tract rarely follows these anastomoses, and, on this basis, some have recommended extension of the indications for such operations.

Several hypotheses have been advanced to explain this supposed difference in reaction between man and dogs, among which are: anatomic differences, greater bacterial content in the digestive canal of the dog, and possibly a greater resistance to infection possessed by the human liver.

When, however, one closely examines the facts, it appears that the conception, that an ascending infection of the biliary tract occurs less frequently in man than in dogs, is not well founded.

While it is true that, in many cases, the anastomosis of the biliary tract to the digestive canal in man is not followed by the development of unfavorable symptoms, this is equally true in animals. Most dogs are apparently healthy after the operation, and cholangitis and hepatitis, even with liver abscesses, may not be discovered until autopsy is performed. Statements that ascending cholangitis rarely develops in man are usually based upon clinical impressions rather than upon evidence from postmortem findings. The more thoroughly the patients are examined after the operation, the more frequently are signs of infection discovered. For example, Bernhard³ reports an inci-

dence of signs of infection in from 10 to 20 per cent of patients, and Hutter⁹ in 11 per cent.

A review of the reported cases of biliary tract anastomosis in man reveals that when the liver has been examined at autopsy signs of cholangitis and hepatitis have been found in most instances.

We have found 20 cases in which definite evidence of infection was found at autopsy: one case with cholecystoduodenostomy,²⁷ nine cases with cholecystogastrostomy,^{9, 12, 18, 20, 21, 23, 28} one case with choledochoduodenostomy,⁴ two cases with cholecystojejunostomy and entero-anastomosis,¹¹ six cases in which the situation of the anastomosis was not noted,^{1, 6, 14} and one case of Judd's cited by Gatewood and Lawton,⁶ in which a patient with cholecystogastrostomy who died of intercurrent disease exhibited hepatitis with abscesses, in spite of the fact that there had been no indication of liver damage before death.

In addition to four cases developing cholangitis following anastomosis of the gallbladder to the gastro-intestinal tract, Leven¹⁴ reported one case in which there was improvement of a previously existing cholangitis after such a procedure. He also reported eight cases which he considered to be normal except for changes which regularly follow biliary obstruction. Those changes, however, included an increase in the amount of portal connective tissue and a periportal round cell infiltration. Since similar changes may be produced by an ascending infection, it is impossible to classify such cases accurately.

We have found only two cases in which the presence of hepatic infection was definitely excluded at autopsy: one case of cholecystogastrostomy¹³ and one case of choledochoduodenostomy.⁸

In interpreting these figures, however, one must remember that some of the infected cases presented evidence of liver injury before the anastomotic operation, and also that cases without cholangitis probably would be less likely to come to autopsy than cases with hepatic damage. Furthermore, as Leven has pointed out, simple biliary obstruction may lead to changes in the liver which present a confusing picture.

Several procedures have been suggested to lessen the danger of infection. Most of these are based on the principle of diverting the chyme from the anastomosis in order to prevent the entrance of infected material from the alimentary canal into the biliary tract. Krause²⁷ established an anastomosis between the gallbladder and the jejunum, and performed entero-anastomosis between the afferent and efferent jejunal loops. Monprofit¹⁹ suggested cholecystojejunostomy in the form of a Y, and Marchetti¹⁷ reported good results after experimenting with this method.

Strauss,²⁵ following the same principle, combined gastro-enterostomy with choledochoduodenostomy in 22 human cases, and reported that he had thus avoided cholangitis. In one of his cases, symptoms of cholangitis which had developed following choledochoduodenostomy disappeared after secondary gastro-enterostomy. Mallet-Guy¹⁶ reported a similar case. On the

other hand, Whipple²⁸ and Hutter⁹ reported three cases in which cholangitis was found at autopsy in spite of the fact that cholecystogastrostomy and gastro-enterostomy had been performed simultaneously.

It is clear that there has been a need for experimental control of the results obtained by procedures such as that advocated by Strauss.²⁵ We have undertaken such a controlled study, and Gentile,⁷ at about the same time, carried out a somewhat similar series of experiments, the results of which he has recently reported.

METHOD.—In a series of 14 dogs, under morphine and ether anesthesia, and using aseptic surgical technic, we anastomosed the gallbladder to the duodenum, interrupted the continuity of the common bile duct (by ligature

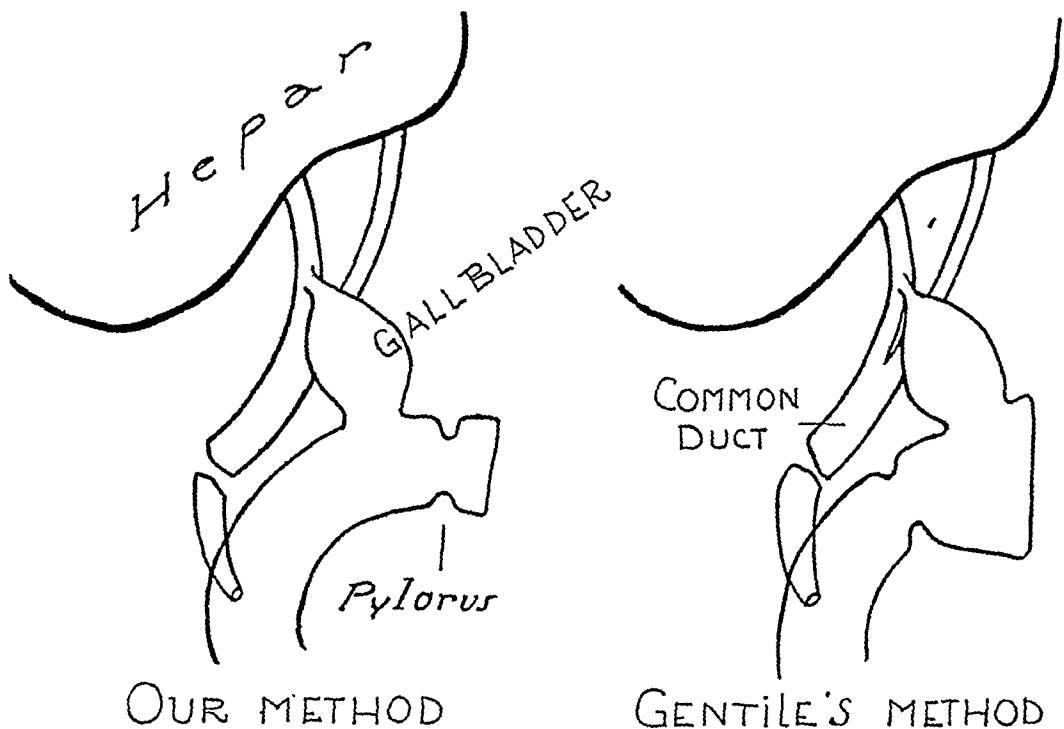


FIG. 1.—Diagram of our operation and that of Gentile.

in one-third, and by division in two-thirds of the cases), excluded the pylorus, and performed gastrojejunostomy in a single stage operation (Fig. 1). At the same time we excised small pieces of the liver and the pancreas for microscopic examination, to serve as controls for comparison with tissue taken at a later date. We added pyloric exclusion to the gastro-enterostomy in order to be more certain of diverting the chyme from the duodenum.

Liver function tests were carried out on all dogs both before and at regular intervals after operation. The tests used were: The diazo test of van den Bergh, the icterus index of Meulengracht, the serum pigment test of Ernest and Forster, the bromsulphalein test of Rosenthal and White, and the blood lipase test of Cherry and Crandall. At the same time the cage urine was collected and tested for bilirubin by the method of Hooper and Whipple.

The dogs were sacrificed with ether at intervals of two to ten months

CHOLECYSTODUODENOSTOMY

TABLE I
POSTOPERATIVE CHANGES

Dog No.	Post-mortem Time After Operation	Circum. of Common Duct Mm.	Circum. of Anastomosis, G. B. to Duodenum Mm.	Grossly Contaminated		B. Coli, Number per 0.1 cc.		Liver Histology		Jejunal Ulcer	Weight Changes % + gain - loss	Comments
				G. B.	Ducts	Periph-erally	Centrally	Peribiliary Infiltration	Infiltration Fat			
1	2 mo.	18	14	+	+	—	—	++	+	0	—	
2	2.3 mo.	20	8	0	0	5	10,000	+	++	0	-17	Purulent cholangitis
3*	3 mo.	15	20	+	+	—	—	+	—	0	-7	
4	3.4 mo.	10	28	+	+	21	25	+	—	0	-13	
5*	4.4 mo.	15	15	+	+	—	—	+	+	+	-17	Perforated ulcer
6	4.5 mo.	20	10	+	+	1	1,000	++	—	+	-30	
7	4.7 mo.	23	10	0	0	300	10,000	+++	—	0	-35	
8*	5.3 mo.	24	16	+	+	—	—	++	—	+	-25	Perforated ulcer Duct reestablished
9	7.8 mo.	12	15	0	0	800	200	+	—	0	-18	Duct reestablished
10	8 mo.	12	10	—	—	0	15	+++	—	+	-44	Concretions
11	8.5 mo.	13	10	+	+	0	1	++	++	0	0	
12	8.5 mo.	10	14	+	+	1	200	+	++	0	+11	
13*	10.7 mo.	16	12	+	0	—	—	+	++	+	-37	
14	10.7 mo.	16	10	+	+	0	0	++	++	0	-10	

* Died.

after operation. For two days prior to sacrifice, finely divided charcoal was mixed with the food so that the path of the ingested material could be easily followed. At the time of the autopsy, small sections were taken with aseptic technic from the center and periphery of the liver and from the spleen (control) for quantitative bacterial study. The biliary tract was examined carefully for gross contamination, and sections of the liver and pancreas were taken for microscopic examination.

RESULTS.—The essential results are recorded briefly in Table I.

Four of the 14 dogs died; one of purulent cholangitis and three from

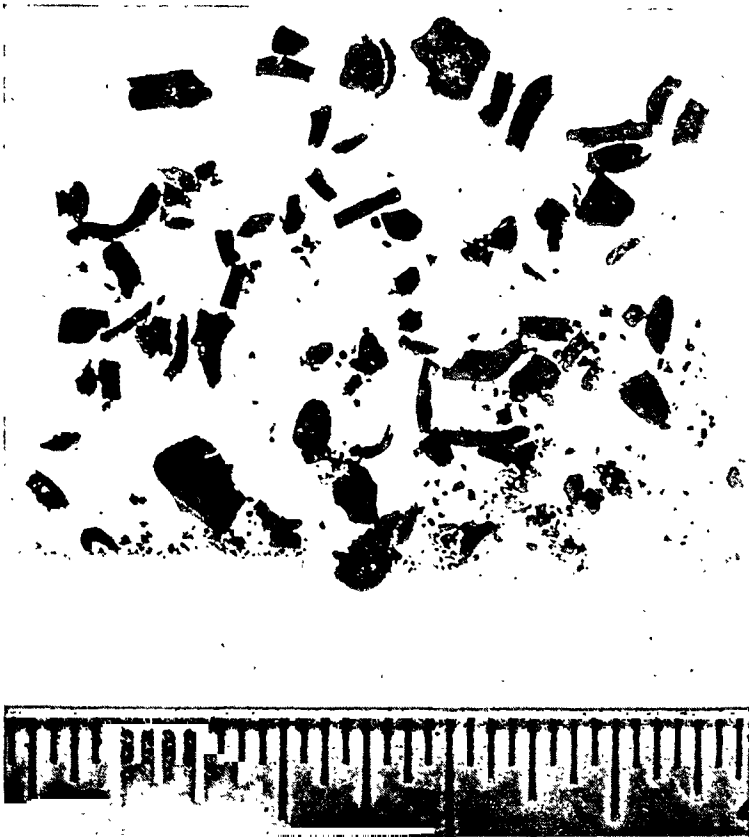


FIG. 2.—Calculi which developed in the biliary tract of Dog 10. The size of the stones may be judged by comparison with the inch rule scale at the side.

complications of jejunal ulcers. The secondary mortality, therefore was 28 per cent, of which only 7 per cent was due directly to liver infection.

In spite of an adequate diet, 12 of the 14 dogs lost weight, and this was most marked in the animals which developed jejunal ulcer.

In five animals (35 per cent), a chronic ulcer developed in the wall of the jejunum opposite to the gastro-enterostomy stoma.

No impairment of liver function could be detected by the use of the several tests enumerated above. Two animals, however, developed a bilirubinuria a short time before they died, and this was interpreted as being due to liver damage.

Autopsy revealed that the continuity of the ductus choledochus had become

reestablished in two cases. In other respects these animals did not differ from the rest of the group. The gallbladder anastomosis was patent in every case, and varied in circumference from eight to 28 millimeters.

Dilatation of the bile ducts was constant. The common duct measured from 10 to 23 millimeters in circumference above the point of its division, whereas normally it measures less than seven millimeters.

There was macroscopic contamination of the biliary passages in ten cases. In six of eight dogs which had been fed charcoal, grains of carbon were found in the biliary tract. In one animal round worms were found in the gallbladder and in the right hepatic duct.

One animal (dog 10) developed numerous calculi in the gallbladder and

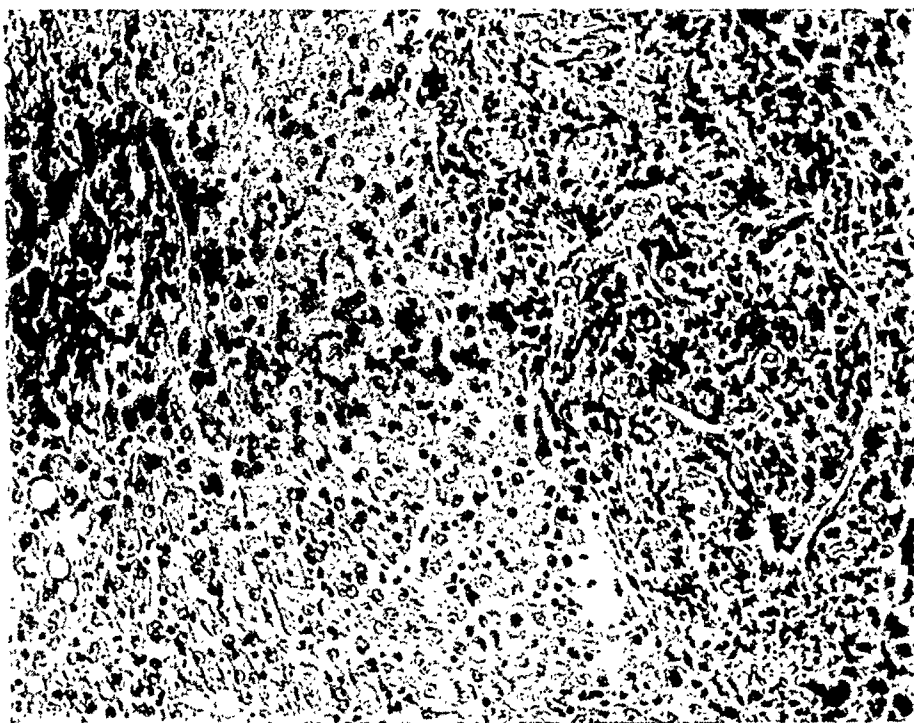


FIG. 3.—Photomicrograph of liver showing severe hepatitis occurring after cholecystoduodenostomy and pyloric exclusion.

ducts (Fig. 2). The concretions in the intrahepatic ducts were golden-brown and tubular. Similar concretions were present in the gallbladder, which also contained larger, irregular, dark-brown, pigment stones. *B. mucosum-cap-sulatum* were isolated from the liver of this animal.

There was no gross pathology evident in the liver in half of the cases. In one case (dog 10) the liver was hobnailed and cirrhotic, and calculi were present in the bile ducts. In another instance (dog 3) there was purulent material in the intrahepatic ducts. In the remaining animals, the only change was the appearance of areas of fatty infiltration which had not been present before the operation (Gage⁵).

Microscopic examination of sections taken at autopsy, compared with controls taken at the time of operation, revealed the pancreas to be normal in all cases. Hepatitis, however, was present in every instance. There was peribiliary infiltration with round and plasma cells, and often with large num-

bers of polymorphonuclear leukocytes (Fig. 3). There was present a fibrosis of varying degree. In half of the dogs the liver cells showed fatty infiltration in some areas.

Quantitative bacteriologic studies were carried out by Dr. W. J. Nungerster, of the Department of Bacteriology. In seven of the nine dogs thus studied, a lactose-fermenting, gram-negative bacillus (presumably *B. coli*) was present in the liver, sometimes in large numbers, and especially in the central portion.

DISCUSSION.—It is evident that none of the tests of liver function which we have used was sufficiently sensitive to detect even severe degrees of ascending hepatic infection. This emphasizes the large factor of safety in the liver, which accounts for the satisfactory general condition of patients even in such serious cases as that of Judd.

Dilatation of the bile ducts constantly follows anastomosis of the biliary tract to the digestive canal. In normal individuals, closure of the sphincter of Oddi shuts off the bile passages from the duodenum during periods when the pressure within the intestine is high.^{15, 22} Removal of this protection permits transmission of pressure into the ducts from the duodenum, and it appears that this transmitted pressure may explain the dilatation. It is probable that infection contributes to the process by weakening the walls of the bile passages.

It would also appear from the results which follow artificial connections between the biliary passages and the gastro-intestinal tract, that the sphincter of Oddi, or the normal choledochoduodenal mechanism, serves not only the well established function of rendering it possible for the gallbladder to fill, but also of preventing or reducing the likelihood of ascending infection of the biliary passages. It would further appear that in the reconstruction of the bile ducts it is preferable to preserve the choledochoduodenal mechanism, when possible.

Cholecystoduodenostomy combined with exclusion of the pylorus, in this study, has invariably led to an ascending infection of the liver. Such an operation, therefore, does not appear to have any definite advantage over simple cholecystoduodenostomy. This conclusion draws further support from Whipple's²⁸ and Hutter's⁹ three cases of cholecystogastrostomy in which simultaneous gastro-enterostomy failed to prevent the development of fatal cholangitis. We entertain serious doubts regarding whether any surgical procedure may be devised which will substitute for the choledochoduodenal mechanism to such an extent as to reduce markedly the tendency toward the occurrence of cholangitis.

Gentile⁷ subjected his dogs to gastric division at some distance from the pylorus, and a Pólya-Balfour anastomosis. Later he established a communication between the gallbladder and the relatively bacteria free, distal, blind end of the stomach. He considered that he had produced by this method conditions comparable to those existing after cholecystogastrostomy in man. His animals, however, would seem to be somewhat more favorably situated

because of the diversion of the chyme, and it would be necessary to divide the stomach in man also, if one desired to duplicate the conditions of his experiment. He reports that the hepatitis which developed in his 22 dogs after cholecystogastrostomy, according to his method, was not more pronounced than after simple exclusion of the pylorus. A survey of his tables, however, shows one case of severe ascending infection with liver abscess and fatal termination, and several cases which showed a marked hepatitis at autopsy. Not even with Gentile's complicated method, therefore, is it possible to avoid



FIG. 4.—Photograph showing jejunal ulcer which developed after cholecystoduodenostomy and gastro-enterostomy with pyloric exclusion. This was the smallest of the five ulcers which developed. Hemorrhage from the ulcer caused the death of the animal.

the danger of ascending infection. Moreover, the secondary mortality in our material, as well as in Gentile's, is considerably increased by a high percentage of jejunal ulcer (Fig. 4). This risk is also present in man (Walzel)²⁶.

The association of ulcer with disturbances of the liver or its secretions has been noted in many instances.^{10, 24} The significance of this relationship is not clear, but the suggestion recently offered by Schnitker and Hass,²⁴ that the peptic ulcer may arise as a result of some deficiency, is interesting.

CONCLUSIONS

(1) Attempts to prevent ascending infection following bile duct anastomosis in dogs, by diverting the chyme so that it does not pass the anastomosis, have been unsuccessful, both in our investigations and those of other experimental surgeons.

(2) To effectively divert the chyme, it is necessary to perform pyloric exclusion in addition to gastro-enterostomy. Even after pyloric exclusion, some of the ingested material makes its way back into the duodenal loop.

Since this procedure undoubtedly adds to the operative risk, in view of our findings it does not seem to be justified.

(3) It appears that ascending infection usually results following bile duct anastomosis in man, as well as in animals. Since the factor of safety in the liver is so large, this infection rarely gives rise to clinical symptoms. Occasionally, however, a fatal infection may ensue, especially if stasis of bile occurs. The development of peptic ulcer in some cases constitutes an added danger. For these reasons it would seem unwise to extend the present indications for this operation.

(4) In the presence of an irremovable obstruction in the terminal portion of the common bile duct, simple anastomosis of the gallbladder to the stomach or duodenum is a satisfactory operation. More complicated procedures add to the operative risk without presenting any definite advantages.

(5) A normally functioning sphincter of Oddi, or choledochoduodenal mechanism, plays an important rôle in the prevention of cholangitis and dilatation of the bile ducts.

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DISCUSSION.—DR. ANDREW C. IVY (Chicago, Ill.) in his remarks closing the discussion stated that one of the functions of the sphincter of Oddi which has been established is that it makes possible the filling of the gallbladder. And I think in the course of time the sphincter of Oddi will be given a second function, namely, that when it is functioning normally it prevents ascending infection and anatomic changes from occurring in the ducts.

The contention that sometimes even though you leave the sphincter of Oddi in place and reconstruct the duct and get cholangitis, the sphincter does not have anything to do with it, does not necessarily follow logically, because we have instances of cholangitis in human beings who have never had their biliary tract operated upon. I should say that we should attempt to preserve the sphincter mechanism whenever possible.

In so far as the development of various complicated and involved operations for anastomosing the biliary passages with the gastro-intestinal tract is concerned, I think the possibilities have just about been exhausted, at least in the dog. In so far as studies on the reconstruction of the ducts, and the incidence of cholangitis after such procedures, are concerned, I do not think the experimental possibilities have been exhausted. I suspect that the clinical possibilities have been exhausted, but should be further analyzed.

In regard to Doctor Douglas' point about the bile salts, I do not think there is any question concerning the point that bile salts when given intravenously or given by mouth stimulate the formation of an increased volume of bile. We have biliary fistula animals in our laboratory now, in which if we drain the bile to the outside, the bile output of the liver decreases; if we divert the bile back into the intestine, the bile output on the same diet increases.

In that connection and in regard to one of Doctor Eliot's remarks, we are now using, with excellent success, Doctor McArthur's procedure in which one catheter is placed into the common duct pointing towards the liver and another smaller catheter is passed through the ampulla into the duodenum. In this way we may administer anything we desire via the intestine. I personally believe that this method has a number of advantages over a T tube.

In doing this work I have in mind a fundamental problem which concerns the surgeon. I am interested in more than the functional activity of the sphincter of Oddi. I should like to discover some way of preventing ascending cholangitis. Not having had the desired success by surgical methods, I have had a man working for about 18 months on biliary antiseptics, with the hope that when we suspect that a cholangitis might occur, we might have some biliary antiseptic to give which would reduce the likelihood of a cholangitis. We have used many of the so called antiseptic dyes and drugs. Surprisingly, the best "antiseptic" we have found to date is salyrgan.

TWENTY-FIVE YEARS' EXPERIENCE IN THE TREATMENT OF PERITONITIS

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IN AN introductory paper on septic peritonitis read before the 1935 meeting of the Northern Surgical Society, Bohmansson¹ failed to submit any statistics, because, as he stated, "we meet with such difficulties in our statistical elaboration of our peritonitis cases that we are unable to understand each other's language and figures." It is surprising to hear such words from a clinician. A careful study, even if burdened with figures, of extensive, uniformly treated, clinical material, with a critical estimation of cases, has always been and will always remain the rock on which we must build up our surgical knowledge. Should we permit ourselves to abandon the method because of its difficulty, we are certain to fall back on mere speculation, personal bias and casuistic chatter. If we really no longer "understand each other's language," it is high time we tried to find out the reason. We must come to an understanding in the question and I am sure we will do so before long.

As a young doctor I was instructed by Lennander, my old teacher, to make a critical study of his material of acute appendiceal peritonitis. This task taught me how necessary it is for a correct view of our clinical experiences to examine case records in detail and without prejudice in the bright, but often unpleasant, light of criticism. The experimental surgeon can, as a rule, create the pathologic conditions he wishes to study from any given starting point and can study critically the methods of treatment he considers useful. This is impossible for the clinician. He does not select his cases; he gets them for observation and treatment. It is only a careful study of his collected material over the course of a long period of time that enables him to obtain a bird's-eye view, minimizing chance coincidence and clarifying the broad aspects of the problem.

My own material comprises all cases observed as senior surgeon in Umeå from 1910 to 1921, in Stocksund from 1922 to 1927, and at the IInd Surgical Department of Sabbatsberg Hospital, Stockholm, from 1928 to 1934. The Umeå hospital had at that time only one senior doctor, who treated both medical and surgical cases. At the Stocksund, as well as at the Sabbatsberg hospitals, there was a separate surgical department. At Stocksund the department also received gynecologic cases. One reason we do not understand each other in our discussions on peritonitis is that we still today speak of it as a uniform disease. We entirely forget that often the only common feature in our peritonitis cases is that the disease takes its course within the human abdominal cavity, and naturally certain com-

mon or similar reactions take place between the organism and the peritoneum. Yet the fact is that the nature and degree of the infection, as well as the different locations and structures of the abdominal organs and their various reactions to external and internal injuries, are of such manifold character that we really must consider a vast number of different forms of peritonitis, forms which frequently have little more in common than the name and each of which demands its specific treatment. As a proof of the validity of this statement I may mention Linzenmeier's² classification of pelvic peritonitis in the female which includes no less than ten well differentiated forms.

Before we enter a general discussion of acute peritonitis we must attempt to solve without confusion all disputable questions concerning each special form of peritonitis. It may be that at some time in the future we may attain this goal and I feel certain that then there will be no more peritonitis to discuss. If we study carefully and conscientiously the origin and development of every form of peritonitis, we shall more and more understand that the only proper treatment, as always, is prophylaxis. Our aim shall then be not to *treat* peritonitis but to *prevent* it. Is it presumptuous to dare to hope for this? I venture to think not. Nearly all patients with peritonitis complain of pain, generally of a very severe nature, and the sufferer knows that he is ill. Fortunately, in most cases of peritonitis there is an interval between the onset of the disease and the point at which it passes into an irreversible stage. This interval varies in length in different forms of peritonitis and it may be very short. We must make use of this interval by removing or shutting out the source of infection. It is true that some forms of peritonitis still exist in which it is difficult to eliminate the source of infection, *e.g.*, pancreatic peritonitis and the purulent form of idiopathic peritonitis, the genesis of which we still do not know or sufficiently understand, but fortunately these forms are quite rare.

Another reason why we often do not understand each other is that we have generally failed to realize, in considering the same form of peritonitis, the importance of the different stages of its development. We compare cases which present certain superficial similarities, but which often possess widely different fundamental characteristics. In this respect, the terms "localized" and "free diffuse" have created and still create a great deal of confusion in the field of appendiceal peritonitis. It is now generally accepted that the exudate in purulent appendiceal peritonitis is in its first stage a free and not a walled off seropurulent fluid. It is later, as the admixture of leukocytes becomes more plentiful, that thick pus develops and fibrin is precipitated, making up the substratum for encapsulation. As a rule, fetid disintegration and encapsulation begin only at the end or at the beginning of the third day after onset of the symptoms. Why an appendiceal peritonitis becomes walled off in one case, and in others tends to spread over a considerable part or the whole of the peritoneal cavity, we do not know in detail; but we have reason to assume that the chief rôles are played by the intensity of the infection,

the spread of destruction in the appendix, and the position of the appendix at the onset of disease. But perhaps most important of all is the bursting of peri-appendiceal abscesses through feeble fibrin walls with discharge of their contents into a previously noninfected abdominal cavity.

When, therefore, we operate upon a patient with appendiceal peritonitis on the first or second day after the onset of the disease we shall find, in the right iliac fossa, or in this fossa and the small pelvis, or in certain exceptional cases in the abdomen below the colon, or in other, also exceptional, cases in the right part of the abdomen toward and in the hypochondrium, a sero-purulent or true purulent fluid, usually odorless and generally without any sign of encapsulation. To give a prognosis on the basis of clinical signs in this stage has proved impossible; it has, therefore, become a conviction, shared by all the world's surgeons, that at this stage operation should be carried out without delay. Should one postpone such an operation, one would find that in a certain number of cases the peritoneal exudate had become absorbed and that the appendix was on the point of organization after its destruction; in other cases a more or less walled off abscess would have formed around the appendix as a nucleus. On the third to fourth day in such cases we would find around the encapsulation another serous to slightly turbid exudate. This, too, however, would be reabsorbed, after which the peritoneal cavity around the encapsulation would resume a perfectly normal appearance. In a third category of cases, proceeding neither to reabsorption nor to encapsulation, one would find a peritonitis extending over varying parts of the abdominal cavity and presenting in its later stages the well known picture of appendiceal peritonitis at the necropsy table—a fetid fibrinopurulent peritonitis with a number of more or less completely walled off pockets of pus.

It will be clear from this description of the various grades and modes of development of appendiceal peritonitis that, as regards its character and prognosis, a purulent appendiceal peritonitis is most imperfectly described by the expressions "localized" or "free diffuse." With few exceptions the term "free diffuse" includes all those cases of purulent appendiceal peritonitis operated on within 48 hours after the onset of the disease, as well as those cases in which Nature's own healing powers have failed to absorb or encapsulate the infection and which make up the majority of all peritonitis cases having a fatal issue. It would seem impossible, even when operation is carried out within 48 hours, to decide with certainty along which of the three lines the individual case might have progressed had no operation been performed. It is true that in some cases an early encapsulation may be noticed, while in others the benign appearance of the exudate may lead one to assume a probable reabsorption or encapsulation. My experience, however, with this and later stages, has taught me the impossibility of determining the prognosis from the gross appearance of the peritonitis. Some cases that appear particularly benign proceed without fail to the postmortem table; others, of an extensive nature with an ugly exudate and greatly altered intestine, pro-

ceed as quietly as any other postoperative case. Thus in the great majority of cases presenting "free diffuse" appendiceal peritonitis at operation, particularly within 48 hours of the onset of illness, there is an intrinsic power of reversibility; in only a few cases is this ability lacking. By these simple facts much is explained that has been considered contradictory, unlikely, and even unexplainable in the literature on appendicitis.

A surgeon who is able to operate upon his cases of appendicitis within 48 hours can point to a low mortality—about 3 per cent. He will be an advocate of small incisions, preferably of "buttonhole" size. He does not recognize the need of getting rid of pus and of drainage ("the exudate is the body's reaction and as such is of positive benefit"), nor has he any difficulty with ileus, and he regards purulent appendiceal peritonitis as a simple disease in which diagnosis is often as simple as the operation and after-treatment. Those of us who have shared in the fight of the first pioneers against appendiceal peritonitis, and who have ourselves treated and unfortunately still have to treat late cases, understand those who complain of their difficulties with free appendiceal peritonitis in cases operated upon after 48 hours. The later cases come to operation, the worse the results.

One dealing with such cases must be content with a mortality of 20 to 60 per cent, must make use of long incisions, and must drain residual abscesses widely. To him it is obvious that, as in every case where an infectious and toxic pus is present, the pus must be removed and the cavity drained; to him the after-treatment with its symptoms of peritonitis ileus becomes a real crux. In every other case of ileus surgery is resorted to, often with brilliant results, but here one employs the whole arsenal of surgery and fails.

If we compare statistics based on the same principles and on similar material, we shall in all probability find that they agree. Should they be found to differ greatly, it will be due to circumstances of which we must be able to find the cause. It may be of interest to compare Bohmansson's statistics and my own (Table I).

TABLE I
Gangrenous Appendicitis without Purulent Peritonitis

	Cases	Deaths	Mortality Per Cent
Bohmansson (1935).....	1,561	7	0.4
Giertz (1935).....	2,000	19	0.8
Appendicitis with abscess			
Bohmansson (1935).....	300	19	6.3
Giertz (1935).....	568	37	6.5
Appendicitis with free (general) purulent peritonitis			
Bohmansson.....	472	68	14.4
Giertz, total number of cases..	1,170	108	9.2
Operated on within 48 hours..	839	29	3.5
Operated on after 48 hours...	331	79	23.0

In passing I must criticize an expression used by many authors when dealing with the appendiceal peritonitis: namely, "perforation peritonitis." If they mean that the appendix is perforated in all cases with general purulent peritonitis, it must be pointed out that their experiences differ greatly from my own. Only about half of these cases present a perforated appendix.

It must be admitted that the two studies agree in a striking manner and differ no more than can be explained by physiologic variations.

On comparing my own material with that from the Uppsala Clinic of 1888 to 1907,³ the result is quite different (Table II).

TABLE II
Purulent Peritonitis within 48 Hours

	Cases	Deaths	Mortality Per Cent
Uppsala material (1888-1907) ..	108	24	22.22
Giertz (1910-1934)	839	29	3.5
General peritonitis after 48 hours			
Uppsala material	100	53	53
Giertz	331	79	23
Localized peritonitis (abscess)			
Uppsala material	325	32	10
Giertz	568	37	6.5

It is at once obvious in Table II, how, in the course of time, operations have come to be performed at an earlier stage of the disease. Of the Uppsala material only 20 per cent of the cases were operated upon within 48 hours; of my own cases 50 per cent. The same tendency is also noticeable in my own material (in Umeå 33 per cent; at Sabbatsberg Hospital, 66.6 per cent).

It was from a study of the literature and the early Uppsala material that I came to understand the errors of Lennander's therapeutic method. It made use of large and numerous incisions, irrigations, enormous tamponades and a highly interfering after-treatment. On my own account and responsibility I began to follow almost entirely opposite principles, including small incisions, no unnecessary interference in the abdomen, and primary closure of early cases (as a rule, all cases within 48 hours). I admit that at first I did fall into the temptation of taking early active measures to prevent ileus. From this, however, I have departed more and more in relying on an expectant after-treatment.

The very considerable reduction from a mortality of 22.22 per cent to a mortality of 3.5 per cent among cases of purulent peritonitis operated upon within 48 hours can be interpreted in only one way: aggressive operative technic and therapy is greatly inferior to simple extirpation through small incisions and with primary closure. Nor is it difficult to find the explanation: the aggressive method with large incisions and drainage interferes in a disturbing manner with the development of Nature's own protective measures.

As to the treatment of walled off peritonitis, there has been no essential change in the method adopted, nor do the results show any improvement that cannot be attributed to earlier operation. In the treatment of general peritonitis after 48 hours I have also followed the new principles by using small primary incisions and opening residual abscesses as the need arises during convalescence. When necessary, drainage has been instituted, usually for abscesses with thick fetid pus and gangrenous walls. The improved results which I have obtained may be explained in part by this technic, but on the whole they are probably due to an earlier and more favorable operative material.

We then arrive at the third cause of the lack of mutual understanding on the question of peritonitis. When speaking of the treatment of these cases, we do not distinguish between operations undertaken for the sake of prophylaxis and those performed for the treatment of an already existing peritonitis and its sequences. In the infancy of abdominal surgery, when, as a rule, one had to face advanced cases with a peritonitis that had almost reached its terminal stage, there was no room for prophylaxis; it was the septic form of peritonitis and ileus with which one had to cope. It was therefore quite natural that the surgeon dealing with earlier stages of the disease brought with him all his views and preconceived ideas from moribund cases and treated early peritonitis as he had treated the late form. We have at last learned to abort a peritonitis by getting rid of the source of infection, and in the treatment of peritonitis already established to relinquish all active measures at operation. Experience has taught us that these so called prophylactic operations must be as simple and noninterfering as possible. However, if we are to carry out purposeful operations through small incisions, our diagnoses must be exact. We must avoid unnecessary exploratory incisions by all the means at our disposal.

When we remember the great possibilities of the roentgenogram in rapidly revealing stones, foreign bodies, free gas in the peritoneal cavity and ileus, it is easy to realize that such an examination has gradually become an absolutely essential aid to our diagnosis in acute cases of difficult interpretation. We must demand, however, that the examination, like all other necessary clinical procedures, be carried out without delay. At the Sabbatsberg Hospital we now have a roentgenologist available at all hours. It may happen, however, that despite all examinations and a careful history, we do not get beyond a diagnosis of diffuse peritonitis of unknown origin. I have learned the advantage in such situations of making a small exploratory incision over the appendix, because appendicitis, "*la grande maladie de l'abdomen*," is, after all, the principal cause of peritonitis. Under all circumstances less damage is caused by a small exploratory incision over the appendix, even if later it is necessary to make an incision in the midline, than by an unnecessary midline incision in the presence of an extensive appendiceal peritonitis.

If one is confronted by the problem of peritonitis complicated by symp-

toms of ileus, one has to consider very carefully what may possibly be gained by active treatment. We would seem by now to have firmly established the impossibility of efficiently liberating a peritoneal cavity from infectious material either by mopping up or by irrigation, and the futility of attempting to drain the whole cavity. It is generally agreed that the only active measure that can safely be carried out in a peritonitis is the drainage and walling off by tamponade of certain parts of the peritoneal cavity, a method we use with success in solitary peri-appendiceal abscesses and residual abscesses after diffuse peritonitis.

In regard to ileus, it occurs in two different forms. One of them is the more or less typical ileus occurring when a loop of the small intestine adheres to itself and kinks until the proximal loop dilates and finally becomes completely incapable of peristalsis. This type occurs not only in forms of fibrinous peritonitis, but also in the initial stage of purulent peritonitis, and often in the case of encapsulated abscesses where coils of small intestine share in the walling off of the abscess. In all such cases of mechanical ileus in which the peritonitis is recent and acute, we must admit the possibility of an explanation of ileus other than the acute flexure. After all, in most cases we deal with a portion of an inflamed and infected small intestine in which the wall is toxically and mechanically affected, often transformed in effect, into a stiff and immobile tube.

The second form of ileus occurs in the fibrinopurulent type of peritonitis spread over the region of the small intestine. This form was previously called inhibited or paralytic ileus. It must now, however, be regarded as settled that the intestine is by no means, as was formerly believed, paralytic in its entirety. The loss of function is probably due partly to mechanical bends and partly to inactivity of certain portions of the jejunum and ileum from toxic or mechanical causes. There is still a great deal that needs explanation in the clinical picture of ileus. Thus, experimental work has been presented lately which tends to disprove the concept of specific toxins arising in the intestine from protein disintegration of the stagnated intestinal contents. Clinically, however, observations have been made that can with difficulty be explained without the assumption of such toxins. It has been definitely established that patients with ileus upon whom a Witzel gastrostomy is performed for the decompression of the upper parts of the jejunum and ileum experience immediate relief from symptoms of threatening circulatory collapse—a livid clammy skin and a faint, rapid, hardly perceptible pulse—symptoms characteristic of acute bacterial intoxication which are generally considered to be due to a peripheral affection of the capillary walls. If such a gastrostomy is closed before the distal obstruction has disappeared a rapid return of the symptoms ensues, with an equally rapid relief after the fistula is again opened. It seems to me that these indisputable facts are hard to explain without assuming the presence of a toxic substance, with a peripheral capillary effect, occurring in the upper ileum in the presence of stasis.

It is tempting for the surgeon to adopt operative measures against ileus.

In many cases of ileus with severe pain, fetal vomiting and a bad general condition, the life-saving operation which at once rapidly alters the clinical picture appears as a miracle. It is human that the surgeon, blinded by his success, should acquire a false belief in surgery as sovereign in all conditions of ileus. One soon learns that the treatment of ileus in cases with and without peritonitis are two fundamentally different things, partly because of the original disease, partly because of the difference between dealing surgically with a small intestine that is sound and one complicated by peritonitis.

During my period of training at Uppsala it was usual to employ a very active treatment for ileus, including gastrostomy, enterostomy, and even operative emptying of the small intestine. Cecostomy and ileostomy were frequently used, gastostomy later and to a less extent. In 1908 I analyzed in detail the material from the Uppsala Clinic and consequently warned against ileostomy. Even at the beginning of my independent work, therefore, I was skeptical about ileostomy, but in practice since then I have not wished to leave any means untried to give the patient a last chance and therefore have occasionally employed ileal fistulae, but only as a last resort. My results will be clear from the accompanying table, which includes a summary of all cases complicated by ileus in which an enterostomy was performed, of laparotomies accompanied by operative emptying of the small intestine and, finally, of all more major operations (Table III).

Altogether, 231 operations were performed. The annual average of operations of this type was at Umeå ten, at Stocksund ten, and at Sabbatsberg six. The average number of abdominal operations annually was: Umeå, 473; Stocksund, 777; Sabbatsberg, 765. Thus, despite an increasing number of cases, there has been a reduced number of operations for fistula, undoubtedly due to the fact that the clinical material has altered and the operative indications have become narrower.

I have divided my material from two main points of view: primary operative treatment for ileus, even at the first operation for the original disease, and secondary operations. Altogether 47 primary operations were carried out, of which there were no less than 34 at the Umeå Hospital, eight at Stocksund and only five at the Sabbatsberg Hospital. These figures indicate chiefly my altered views on the necessity and justification of the primary operation.

The second main group is concerned with operations for ileus in appendiceal peritonitis and ileus in other diseases. The first group is by far the larger, with 150 cases. The latter group includes 39 cases of peritonitis, the etiologic factor in which was other than appendicitis, and 42 cases of ileus without peritonitis. I have been unable to convince myself of the necessity of primary operations and, moreover, I have learned to understand how impossible it is to judge from the appearance of the peritonitis at the first operation whether or not it will be complicated by ileus. Without this qualification we operate on chance and carry out procedures which are often unnecessary and which may be harmful to the patient. This is particularly

true as regards the emptying of the small intestine as suggested by Dahlgren.⁴ The primary major operations included in Table III concern all those patients with symptoms of ileus and walled off peritonitis in whom abscesses have been drained and intestinal obstruction excluded by means of anastomoses.

TABLE III

GASTRIC AND INTESTINAL FISTULAE, DRAINAGE OF THE SMALL INTESTINE
AND OTHER OPERATIONS FOR RELIEF OF THE GUT

	Primary In Appendicitis		Fistulae In Other Diseases		Postoper. In Appendicitis		Fistulae In Other Diseases		Total	
Umeå 1910-1921.....	19		15		48		39		121	
Stocksund 1922-1927.....	8		..		33		22		63	
Sabbatsberg 1928-1934.....	4		1		38		4		47	
Totals.....	31		16		119		65		231	
	Cases	Dead	Cases	Dead	Cases	Dead	Cases	Dead	Cases	Dead
Cecostomy.....	14	4	..	..	13	6	6	4	33	14
Gastrostomy.....	2	1	..	..	27	15	5	5	34	21
Gastrostomy and cecostomy..	5	0	11	9	35	31	18	16	69	56
Operative emptying of small intestine plus gastrostomy and possibly cecostomy....	4	4	4	1	15	8	11	8	34	21
Operative emptying of small intestine and possibly ce- costomy.....	2	0	..	..	3	2	12	10	17	12
Operative emptying of small intestine and ileostomy.....	..	..	..	..	1	0	..	..	1	0
Ileostomy.....	..	..	1	1	10	9	12	11	23	21
Second laparotomy with free- ing of adhesions.....	..	..	..	..	4	0	..	..	4	0
Second laparotomy with ileo- ileostomy plus gastrostomy.	1	0	..	..	2	1	..	..	3	1
Second laparotomy with ileo- transversostomy plus gas- trostomy.....	3	1	..	..	6	4	1	1	10	6
Second laparotomy with re- section of small intestine and gastrostomy.....	..	..	..	..	2	2	..	..	2	2
Second laparotomy with ileo- cecal resection and gas- trostomy.....	..	..	..	..	1	0	..	..	1	0
Totals.....	31	10	16	11	119	78	65	55	231	154

As to secondary operations, ileostomy was performed in 23 cases in all, with 20 deaths. The patients saved by ileostomy were in two instances of pelvic abscesses following appendicitis, and in one instance fibrinous peritonitis without any demonstrable cause complicated by ileus. In the latter case cecostomy and gastrostomy were first performed, as well as emptying of the small intestine. Immediately ileus again supervened, at the second laparotomy the intestines were found adherent, expanded and friable. An ileostomy seemed the only feasible procedure, which subsequently caused marked maceration of the skin. Finally a third operation, resection of the intestine, resulted in ultimate recovery. In all other cases in which ileostomy had been performed, those with and those without peritonitis, the procedure proved quite useless. All the patients died despite the fistulae.

At last year's German surgical congress, Nordman⁵ stated that he considered cecostomy to be superfluous. I am in agreement with him and have practically discarded this procedure. I have also abandoned the heroic measure of intestinal emptying which, particularly in peritonitis, must be considered a distinctly dangerous undertaking, not only because the intestine itself is usually friable and likely to suffer irreversible damage, but also because one may encounter unexpectedly an intra-abdominal abscess which may spread and cause an exacerbation of the peritonitis.

A Witzel's gastrostomy, on the other hand, is easy to perform. In contrast to the nasal catheter, with which I have had only slight experience, it causes little discomfort and generally closes immediately after removal of the tube. I think it is important that this tube, intended for drainage of the intestinal contents regurgitating into the jejunum, should be laid through the pylorus for some distance down into the duodenum. It happens that a gastrostomy thus made may very occasionally cause trouble, because the tip and side openings of the tube get caught by the valvulae conniventes of the duodenum. There have been patients in whom, despite a properly made fistula, nothing has passed either upwards through the fistula or downwards through the rectum, although at necropsy the small intestine was found dilated.

A definite effect of gastrostomy is the patient's objective as well as subjective improvement. He no longer suffers from fecal vomiting. With the fistula open he is able to take fluids without trouble, which is a very great relief. The feeling of oppression and, most important of all, the grave circulatory disturbances, disappear.

The number of cases is quite small for the evaluation of results—III in all with a mortality of 72 per cent.

In appendiceal peritonitis.	77 cases	54 deaths	71.4% mortality
In other forms of peritonitis and ileus.	34 cases	24 deaths	72 % mortality

I am unable to say, as in the cases of ileostomy, that the gastrostomies were made on vital indications. Among those who did not succumb there were undoubtedly a good many who would have recovered without gastrostomy.

Among other major operations for ileus there were four cases of ileus from adhesions without a fatality. In all these cases there were severe inflammatory changes in the ileocecal region, especially of the lowermost part of the ileum, with adhesions which one neither could nor would wish to free.

The two cases of intestinal resection, both fatal, were hopeless. At operation for the obstruction such damage was caused to the intestines that only resection was likely to bring any relief.

In the last analysis it must be admitted that our ability to influence the progress of ileus by this method is very limited. *The only way of eliminating the difficulties is to improve prophylaxis and this means early operation for all abdominal cases that may be complicated by peritonitis.*

Table IV gives a brief review of the clinical material during this period (1910-1934). The number of abdominal operations was 16,815.

TABLE IV

Total Number of Abdominal Operations

Umea	1910-1921.....	6,825 cases
Stocksund	1922-1927.....	4,634 cases
Sabbatsberg	1928-1934.....	5,356 cases
Total.....		16,815 cases

Gangrenous Acute Appendicitis

Without purulent peritonitis.....	2,000 cases	19 deaths	0.95% mortality
With purulent peritonitis.....	1,728 cases	145 deaths	8.35% mortality
Totals.....	3,728 cases	164 deaths	4.4% mortality

Other Cases of Acute Peritonitis

Perforated gastric ulcer.....	149 cases	33 deaths	22.1% mortality
Gallbladder peritonitis.....	43 cases	14 deaths	32% mortality
Acute pancreatitis.....	33 cases	23 deaths	70% mortality
Acute general purulent peritonitis. Cause?...	29 cases	15 deaths	52% mortality
Empyema peritonei and abdominal abscesses of unknown etiology.....	15 cases	.. deaths	0% mortality
Acute traumatic and other perforations of hollow organs.....	24 cases	16 deaths	67% mortality
Various.....	6 cases	2 deaths	
Totals.....	299 cases	103 deaths	34.4% mortality

There have been observed 2,027 cases of purulent peritonitis with 248 deaths (12.2 per cent). Peritonitis in connection with the female genitalia has not been included in this investigation. The majority of these cases are made up of purulent appendiceal peritonitis—1,728 cases with 145 deaths (8.35 per cent). All other forms of peritonitis amount to only 299 cases with 103 deaths (34.4 per cent). This latter group consists principally of perforated ulcers, 149 cases with 22.1 per cent mortality. There were in addition 43 cases of gallbladder peritonitis with a mortality of 32 per cent, 33 cases of acute pancreatitis with a mortality of 70 per cent, and 29 cases of ideopathic general purulent peritonitis with a mortality of 52 per cent. Fifteen cases were grouped under empyema peritonei and other abdominal abscesses of unknown etiology, with no deaths. There were 24 cases of acute traumatic and other perforations of hollow organs with a mortality of 67 per cent, and of more unusual forms there were six cases and two deaths. Four of these six cases proved to be actinomycosis with only one death.

The overshadowing importance of appendicitis in the abdominal material that is encountered by the Surgeon-in-Chief of a community hospital in Sweden becomes still more obvious if one remembers that beyond these 1,728 cases of purulent appendiceal peritonitis have been under treatment

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2,000 cases of gangrenous appendicitis with or without only serous fibrinous peritonitis, with 19 deaths (0.95 per cent mortality). Finally, there are still 1,633 cases of acute non-destructive appendicitis with eight deaths (0.50 per cent). The sum total of appendiceal cases thus amounts to 5,361 with 172 deaths (3.2 per cent) (Table V).

TABLE V

ACUTE APPENDICITIS										
		Umeå ^o 1910-1921		Stocksund 1922-1927		Sabbatsberg 1928-1934		Total		
		Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	
I. Without purulent peritonitis										
A. Nongangrenous acute appendicitis.....										
		800	2	328	1	505	5	1,633	8	0.5% mortality
B. Gangrenous appendicitis.....										
		493	6	439	5	1,068	8	2,000	19	0.95% mortality
II. Gangrenous appendicitis with purulent peritonitis										
A. Early peritonitis										
< 48 h.....		224	5	216	8	399	16	839	29	3.5% mortality
B. Late peritonitis > 48 h.										
a. free general.....		125	36	101	25	95	18	321	79	23% mortality
b. walled off.....		334	20	128	11	106	6	568	37	6.5% mortality
Totals.....		683	61	445	44	600	40	1,728	145	8.35% mortality
Sum totals.....		1,976	69	1,212	50	2,173	53	5,361	172	3.2% mortality

In the foregoing I have dealt with *appendiceal peritonitis*. When we urge early operation we imply an early and exact diagnosis; without such we come to slaughter “en masse” or to extirpation of appendices for reasons other than the patient’s health and safety.

Two further methods of investigation of great assistance in diagnosis have come in recent years to be used in every acute abdominal case: the white blood count and determination of the sedimentation rate. These examinations have been carried out routinely at the Sabbatsberg Hospital since 1928. In the cases of acute appendicitis the material has been studied by one of my assistants. Although I am unable as yet to submit any exact figures, in general the results of this investigation are that in acute gangrenous appendicitis an increase in the number of leukocytes, generally to 10,000–14,000 per cm. and not infrequently above 20,000, takes place in by far the greatest number of cases. The sedimentation rate, on the other hand, is normal during the first few days. If, therefore, in a patient with acute abdominal pain we find a high sedimentation rate and a low leukocyte count, the appendix is probably not the source of the peritonitis. And the contrary holds true: an acute abdominal case with a typical history of appendicitis, even without a rise in temperature, increased pulse rate and abdominal tenderness, but with a low sedimentation rate and a high leukocyte count, is operated upon for destructive appendicitis.

However experienced we become in the course of years and however con-

scientious we are in our observations, we have to face almost daily patients with acute abdominal pain on whom we are unable to make an exact diagnosis and in whom we are unable to exclude the possibility of appendicitis. In such cases I perform, on principle, an exploratory laparotomy over the appendiceal region.

For a long time I have been trying, clinically and statistically, to find an answer to several important questions which must be solved:

(1) How often do we make a diagnosis of acute gangrenous appendicitis and yet find a normal appendix at operation?

(2) How often do we operate with an uncertain diagnosis, believing acute appendicitis cannot be excluded, and find a gangrenous appendix at operation?

(3) How are we to explain the symptoms if, at such exploratory laparotomy, the processus veriformis is found to be perfectly normal? As we all know, a great number of patients exist, particularly women, who subjectively present such suspicious symptoms of appendicitis as to demand an exploratory laparotomy, but in whom operation reveals nothing.

(4) What risks do these patients run if submitted to an exploratory laparotomy and how great are these risks as compared with the risk of non-operative treatment?

That all risk is not absent in the removal of an appendix, even when there are no signs of gangrene, is also evident from the eight deaths among 1,633 operated cases, a mortality of 0.5 per cent (Table VI).

In five cases the cause of death was a pulmonary embolus which occurred no less than 17 times in the whole series, and in one case the cause of death was a technical error. Extirpation of the appendix in the free interval or while in a mildly inflammatory stage without peritonitis is one of the easiest abdominal operations, and can safely be carried out by young and relatively inexperienced assistants. However, when the symptoms are more than 48 hours old one can never be certain what surprises lie in wait for one. For a long time, therefore, I have allowed no one but the two senior assistants or myself to operate upon patients with peritonitis and acute appendicitis who have been ill for more than 48 hours.

The two other deaths occurring in acute nongangrenous appendicitis were caused by septicemia from a widespread phlegmon of the abdominal wall. In both cases the appendix was unfortunately not examined microscopically. For many years we have verified all appendices microscopically. Experience has taught me that appendices regarded as grossly as "gangrenous in the mucous membrane" have often presented microscopically no such changes, and appendices that appeared innocuous at operation have not infrequently been found greatly altered on microscopic examination.

If we adopt primary closure of the wound as an arbitrary principle in the treatment of peritonitis, experience must soon tell us whether or not there is any inherent danger in the procedure. This danger presented itself in my series as a severe phlegmon of the abdominal wall, which required

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secondary incisions (31 cases). In eight cases in which no peritonitis was found this plegmon of the abdominal wall so dominated the whole clinical picture that death must be regarded as the result thereof. In the other fatal cases (five) there was at the same time a widespread purulent peritonitis, making it difficult to assess to what extent the abdominal phlegmon was the cause of the fatal issue.

TABLE VI
CAUSES OF DEATH IN APPENDICITIS

	Without Purulent Peritonitis		With Purulent Peritonitis			Totals
	Nongan- grenous	Gan- grenous	<48 h.	>48 h. Free	Walled off	
<i>Complications</i>						
Pulmonary emboli	5	5	2	1	4	17
Technical operative error	1	..	..	..	..	1
Pneumonia	..	1	..	2	2	5
Lung abscess	..	1	..	..	1	2
Synechia pericardii	..	..	..	..	1	1
Tbc. pulm. miliaris	..	..	1	..	1	2
Cerebral hemorrhage	..	..	..	1	..	1
Totals	6	7	3	4	9	29
<i>Peritoneal Infections</i>						
Septicemia	2	6	..	..	8	16
Peritonitis	..	..	4	32	4	40
Peritonitis with ileus symptoms	..	..	17	30	5	52
Paralytic ileus	..	..	4	3	..	7
Mechanical ileus	..	4	..	1	8	13
Healing peritonitis with ileus symptoms plus pneumonia	..	..	..	6	2	8
Healing peritonitis with ileus plus thrombosis of vena cava	..	..	..	1	..	1
Purulent pericarditis	..	..	..	..	1	1
Mesenteric venous thrombosis and liver abscess	..	2	1	2	..	5
Totals	2	12	26	75	28	143
Sum totals	8	19	29	79	37	172

Residual abscesses must also be considered. The commonest of these is the pouch of Douglas abscess which occurred in 123 cases with 11 deaths. If we realize that most of these abscess operations were carried out in cases of appendiceal peritonitis of widespread character, it is clear that the production of a pelvic abscess indicates a good reaction of the body and is, therefore, a favorable sign. There are other intra-abdominal residual abscesses

that often must be opened. Nonsubphrenic abscesses, usually located in the left iliac fossa, have been encountered in 38 cases with four deaths. Subphrenic abscesses occurred in 11 cases with three deaths.

For the sake of completeness I would like to report on subphrenic abscesses arising from causes other than appendicitis (Table VII).

TABLE VII

SUBPHRENIC ABSCESES RESULTING FROM OTHER THAN APPENDICITIS

In infection of the gallbladder	3 cases	1 death	1 case not operated upon
In gastric ulcer and perforated duodenal ulcer	5 cases	4 deaths	
In gunshot wound of the stomach	1 case	0 deaths	
In rupture of the liver	1 case	1 death	
In retroperitoneal tumor	1 case	1 death	
After operation for fibrous peritonitis	1 case	1 death	
Cause unknown	1 case	0 deaths	
		<hr/>	
		13 cases	8 deaths

The tabulation of the causes of death in purulent peritonitis includes only well known conditions. In this connection, it may be mentioned that the total number of observed cases of liver abscess in cases of appendicitis amounted to six with as many deaths. In two patients, both dead from concurrent peritonitis, the abscess was discovered at postmortem. Incision and drainage were carried out in the other patients. There was only one liver abscess with an origin other than appendicitis and this followed perforation of a gastric ulcer.

In regard to perforated peptic ulcer, there was an annual average of three to four cases at Umeå, six at Stocksund, and ten in Stockholm (Table VIII).

The improved results in recent years may be due in part to a more correct, more certain and more consistent selection of operative methods, but to a large extent it is explained by the fact that in recent years in Stockholm patients have been reaching us in an operable condition. They are now sent directly to the hospital at the onset of pain. The primary principle to be borne in mind is that the peritonitis must be treated before the ulcer disease. Should the patient not be in good condition or if more than four hours have elapsed since the perforation, if there should be any contra-indication to a major operation after exploration of the abdomen or if the operator is insufficiently experienced to perform gastro-enterostomy or resection with ordinary risk, nothing is done save closure of the ulcer, possibly after excision of its margins and a Witzel gastrostomy. In these cases in which the gastrostomy is intended only for relief of the stomach, the tube is placed with the tip toward the cardia and the abdomen is primarily closed. In the course of the last three years, 1932 to 1934, we have operated upon 27 cases with only one death. The single fatality was a patient who had been ill for seven days and was beyond surgical help. Only incision and drainage were carried out. In the other 26 cases gastro-enterostomy was performed on two

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patients and resections on two; in the remainder only suture and gastrostomies were performed.

TABLE VIII

PERFORATED GASTRIC AND DUODENAL ULCER

	Umeå 1910-1921	Stocksund 1922-1927	Sabbatsberg 1928-1934	Totals	Mortality
Operative Method					
Suture of ulcer with primary closure of wound (usually gastrostomy).....	10-4	9-5	49-9	68-18	26.5%
Suture of ulcer and gastro-enterostomy with primary closure of wound (usually gastrostomy).....	28-7	24-4	9-0	61-11	17%
Resection with primary closure of wound (usually gastrostomy).....	1-0	4-1	9-1	14-2	15%
Drainage without suture of ulcer with gastrostomy.....	3-0	....	1-1	4-1	
Operation for perforated jejunal ulcer.....	1-0	....	....	1-0	
Drainage of perigastric abscess.	1-1	....	....	1-1	
Totals.....	44 12	37 10	68 11	149 33	

CAUSES OF DEATH

	Umeå 1910-1921	Stocksund 1922-1927	Sabbatsberg 1928-1934	Totals
Peritonitis—septicemia ileus...	7	7	9	23
Postoperative shock, 1; pneumonia, 5; lung gangrene, 1; circulus vitios following gastro-enterostomy, 2; volvulus, 1.....	5	3	2	10
Totals.....	12	10	11	33

The cause of death in 23 of the 33 fatalities was a direct result of peritonitis (septicemic peritonitis—ileus). In ten cases (30 per cent) death was due to causes not directly connected with the disease as such. In no less than nine of these ten cases death must have been related to the operation (Table VIII). During my tenure as assistant to Lennander a perforated ulcer that could be saved was almost a miracle; in a report on cases published in 1898 only two out of 11 cases survived, a mortality of 82 per cent. If we take into consideration the large incisions used at that time and all attempts at cleaning and drainage of the abdominal cavity, as well as interfering after-treatment, and compare this with our present simple operative method and expectant after-treatment, it must surely be admitted that figures and analyses of cases speak a language that cannot be misunderstood.

In the course of the past 25 years 1,017 gallbladder operations have been

carried out with 96 deaths, a mortality of 9 per cent. Only 43 of these cases were complicated by purulent peritonitis; in 26 the peritonitis was general, in 17 walled off, and 14 died (33 per cent). My figures show how the gallbladder material in these years has increased in our hospitals. During the Umeå period there was an annual average of ten cases, at Stocksund of 55, and at Sabbatsberg of 82. I have not prepared this material sufficiently to be able to give a detailed account of the significance of the figures. However, it is clear that a diseased gallbladder, even if highly gangrenous, rarely gives rise to a peritonitis, and that this peritonitis is as a rule mild in character. Another characteristic feature of gallbladder peritonitis is its rare complication with ileus. The high death rate is not usually due to the peritonitis, as such, but to the original disease, inflammation of the bile tracts and calculi, which, in those cases that lead to peritonitis or pericholecystic abscess, is complicated and difficult to treat.

A disease about which a great deal is written, although I have had difficulty in reaching a real understanding of it through studies of the literature, is *pneumococcal peritonitis*. Nor has my experience with this disease brought me any enlightenment. In the course of 25 years I have seen three cases of walled off umbilical abscesses (so called empyema peritonei). The clinical features of these cases have agreed with those described as characteristic of a chronic form of pneumococcal peritonitis. These abscesses have been of benign nature and have cleared up after incision.

During the same period I have further observed 29 cases of acute purulent peritonitis in which neither at operation nor necropsy (15 deaths) could any local cause of peritonitis be found. Unfortunately, in none of these cases was a very careful bacteriologic examination possible. In two cases, both dead, I have ventured the diagnosis "probably pneumococcal peritonitis." In three cases the peritonitis was labeled metastatic and in two cases it probably arose from a simultaneous tonsillitis; in the latter the course was very acute. All cases were operated upon, since I believe that a gangrenous appendicitis can never be ruled out without operation.

In the past 25 years three cases of gangrenous appendicitis have been admitted in good time for a prophylactic operation, but because of mistaken diagnoses operation was not carried out until too late, after aggravation of the symptoms had made operation necessary. Diagnoses of pneumonia were made in two cases and salpingitis in the other.

In all the 29 cases just mentioned the appendix was macroscopically as well as microscopically normal. In a fatal case of peritonitis in a girl the tubes and uterus were found to be microscopically normal. In eight patients, five of whom recovered, a normal appendix was left to avoid unnecessarily prolonging the operation. Whether this procedure darkened the prognosis of any of those 15 patients who died after the operation I do not know, but there is no evidence to support such a suggestion. I am quite convinced that these 29 cases may be referred to widely different types of peritonitis.

Thus in our work we occasionally meet with cases of acute purulent

general peritonitis in which we are unable definitely to establish the etiologic factor. Some of them are undoubtedly of the pneumococcal type, and others metastatic (in connection with purulent pleurisy and pericarditis). I believe it is evident from my statistics that there is little harm in exploratory laparotomy in these cases.

There is a disease of childhood, however, *during which exploratory laparotomy in the acute stage is undoubtedly an operation to be avoided: namely, scarlet fever*. Two female infants who had been taken acutely ill with fever, vomiting, and diffuse abdominal pains, and who had been admitted to the hospital without any thought of scarlet fever, were subjected to exploratory laparotomy on a presumptive diagnosis of acute gangrenous appendicitis. In both cases the appendix proved blameless and there were no signs of peritonitis. In both a severe form of streptococcal peritonitis developed which led to death in one. The other girl recovered but only after prolonged suffering and a number of incisions for residual abscesses in the abdomen and below the diaphragm.

All the localized abscesses in the abdomen which were without ascertainable starting point¹² proved to be benign. In one case there were multi-ocular abscesses with ileus in which 190 cm. of the small intestine had to be resected. Recovery followed. In two cases of abscesses in the right iliac fossa and the right lumbar region quite normal appendices were removed. These lay outside the abscesses concerned (Table IX).

TABLE IX

Perforated Injuries from External Violence

Gunshot wound of stomach.....	2 cases	0 deaths
Gunshot wound of colon.....	3 cases	1 death

Subcutaneous Perforations

Rupture of biliary tract.....	1 case	0 deaths
Rupture of ileum.....	4 cases	4 deaths
Rupture of colon.....	2 cases	2 deaths

Totals.....	12 cases	7 deaths
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In perforation of diseased hollow organs the original disease was:

Typhus, 2 cases; tbc, 1; hernia, 2; infected tumor, 2.....	7 cases	5 deaths
Diverticula coli.....	4 cases	4 deaths
Meckel's diverticulum.....	1 case	0 deaths

CONCLUSIONS

We must realize that we cannot treat acute peritonitis according to a set pattern or by a fixed method for all cases. We must learn to treat peritonitis methodically; that is to say, we must realize that there is not one form of peritonitis but many, each with its special etiology, peculiar symptomatology and specific pathologic anatomy. Naturally, all have well marked features in common because they occur in the same human body.

We must realize that cases of purulent peritonitis demand the most accurate diagnosis, because on this the treatment depends, and in peritonitis more than in any other disease treatment is a life or death matter. While one case may demand a rapid and purposeful surgical intervention, another may require an equally purposeful nonsurgical measure. A mistake on the part of the surgeon may cost the patient his life. It must be understood that one type of peritonitis in different stages of its development presents various clinical pictures and therefore requires different forms of treatment.

First and last we must remember that, even with the aid of surgical and other means, our chances to help a patient with peritonitis in advanced stages are very small. The victories we have gained in the course of the past twenty-five years, and which we are able to estimate statistically, are due to our understanding of the prevention of peritonitis through early prophylactic operations. For further success we must proceed along the same course, which means continued enlightenment of the public regarding the very great risk of life inherent in delay in the treatment of acute abdominal pain.

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DISCUSSION.—DR. FRANZ TOREK (Montclair, N. J.).—I think we are to be congratulated upon having heard Professor Giertz' exposition of this condition. As he has mentioned, the surgeon is often confronted with the fact that at the time when he is called in it is too late for prophylaxis, but the surgeon has to interfere immediately.

As for the method of interference, I think we are all agreed upon certain points, namely, that if the condition is either localized by adhesions, or if it is a free peritonitis of moderate extent, we confine our interference to the part that is involved, being careful not to spread it any further. We accomplish this by walling off the affected area and avoid touching those parts which are still uninvolved.

It is different if we have to deal with a diffuse suppurative peritonitis, especially that following appendicitis. By the term "diffuse" I mean a condition in which the suppurative peritonitis has extended well over to the opposite side, and high up. In reference to this class of case I wish to call attention to 36 case reports cited many years ago, which were seen early in my career. Later on, the diffuse cases became more and more rare, which of course I believe is due to the fact that we recognize the condition earlier and operate earlier.

I shall not go into all the details, but refer you to the transactions of this society for 1932, page 69. I should like, however, to consider some of the principles involved. It is important that all the pus must be evacuated. If the procedure is such as to give only partial relief from the infection, with

considerable accumulations of pus left behind, I think the patient is usually doomed. That such pockets may exist I learned very early in my observations. After allowing all the pus to flow out, I would find adjacent coils of intestine behind which large amounts of pus were concealed. All portions of the peritoneum must be reached, and the only way I felt I could accomplish this was through a large incision. From pubes to umbilicus is not sufficient. The incision must go higher than the umbilicus, affording access to all the intestine, so as to permit handling them as gently as possible. This can best be effected by a stream of water. I have been employing large quantities of saline solution, aiding the lavage with the gloved hand to move the intestines very gently from side to side, to be sure it will reach all parts.

That, of course, is done in a certain order, after the opening is made and the free pus evacuated, sometimes in enormous quantities. I recall one case in which, at the first nick in the peritoneum, the pus spouted up a foot or more. By the way, that was one of the successful cases.

The orderly procedure would be first to go into the region of the appendix, to remove it as quickly as possible and wash out that gutter. Next wash out the pelvis and after that clean the left gutter. After everything is grossly clean, and the water returns clear, I believe the peritoneum will be capable of coping with any residual infection.

After this is accomplished, the abdomen is closed without drainage. That is important, I believe, because whatever drainage might result can only do harm. You cannot drain the entire peritoneal cavity. Consequently, you have to depend upon the ability of the peritoneum to overcome what infection is left.

As to my results: I published them in two sections, each one detailing 18 cases, and the results in both groups were the same; namely, one death in every six patients, making a mortality of 16.66 per cent. Subsequent to the compilation of the above statistics I operated upon four other cases without a death, which reduces the mortality to 15 per cent.

DR. ALTON OCHSNER (New Orleans, La.).—Whereas the mortality rate immediately after the production of a peritonitis may be due to the absorption of toxin by the peritoneum, those cases that live after the peritoneal reaction has occurred die mostly of the ileus which Professor Giertz referred to. The adynamic ileus can be readily and easily combated by relatively simple measures, such as the decompression suggested by Wangensteen with the indwelling duodenal catheter and suction, and the administration of large doses of morphine as suggested by Orr and Clark. Doctor Orr has presented before this Association his results, showing that morphine is a stimulant to intestinal activity rather than an inhibitant. If one will give these patients large doses of morphine and keep them well narcotized until their peritoneal reaction has subsided, their ileus will largely be taken care of.

Several years ago we began using oxygen, with the idea of combating an anoxemia, and our results are gratifying. Recently Fine, of Boston, has shown that the inhalations of oxygen are beneficial in hastening the absorption of retained gas in intestinal loops. Personally, I feel that this is a great contribution, and I feel that these patients with intestinal ileus, of any type, irrespective of the cause (and in these cases it is usually the adynamic variety) should be given large doses of morphine and oxygen.

In addition to this, the application of heat to the abdomen is of value, probably because, as Mueller has shown, it produces a vasodilatation of the somatic vessels and a constriction of the splanchnic vessels, which in turn favors the relief of the ileus.

DR. OWEN H. WANGENSTEEN (Minneapolis, Minn.).—Certainly Professor Giertz should be commended for this discerning and well tempered dissertation relating to peritonitis; and I find myself in practical accord with the principles which he has enunciated. He has alluded to the fact that in the presence of peritonitis, the surgeon not uncommonly does harm and spreads the peritonitis by badly timed operative intervention. This is an experience which I have also had. We have lived through a few decades, during which time "acute abdomen" has been synonymous with operation. We now stand, I am inclined to believe, on the brink of a new era in abdominal surgery, as it relates to the acute abdomen, in which one will not arbitrarily operate because an acute abdominal lesion is present. The criteria which *demand* operation must be defined; no longer is "acute abdomen" to be considered synonymous with necessity for operative intervention. Operation is to be undertaken only on adequate indication and when it is believed that something may be accomplished by it.

I would agree that every patient with acute appendicitis should be operated upon early. In instances of perforation of the gastro-intestinal canal, whether of the stomach, small intestine, or colon, operation is urgently indicated to close the leak. In all strangulating types of obstruction and in acute obstructions of the colon with considerable distension, immediate operation is in order. Experience has adequately shown, however, that frequently in mechanical obstruction of the small bowel due to adhesion, decompression can be effected through the agency of suction applied to an inlying duodenal tube without recourse to operation. I see very little necessity for frequent operative attack upon the so called acute gallbladder. Practice has shown, in the main, that conservative, nonoperative treatment of biliary colic is safe. To be sure, an occasional case will demand operation. Those who frequently practise and urge excision of the "acute gallbladder" are apparently unmindful of the fact that the gallbladder, when obstructed, is not as treacherous as is the appendix. It is my belief that if one took two parallel series of 100 "acute gallbladders" and operated upon all in one, and none in the other, that there would be more lives saved in the group in which operative restraint was practised. If in addition, in the conservatively treated group, one individualized the cases after careful scrutiny and urged operation upon those where it was manifestly needed, the salvage of life would be further increased.

Moreover, I see but slight indication for operation in instances of pancreatic necrosis. The diagnosis in most instances can be made without operation with some assurance on the criteria which I have elsewhere described. (Minn. Med., 15, 201, March, 1932.) The operative measures which have been employed in this condition are essentially three: (1) drainage of the peritoneal cavity, (2) drainage of the biliary tract, (3) tamponade of the pancreas. None of these is in any sense a specific remedial measure. Patients die of pancreatitis because of autodigestion of the pancreas. What is needed is some agency which will interfere with the activation of trypsinogen within the pancreas. Partial removal of the normal activator of the pancreatic ferments, succus entericus, from the lumen of the duodenum by suction, starvation, and the administration of atropin are probably just as effectual in this respect as are the nonspecific operative procedures commonly employed.

Professor Giertz has rightfully stressed the importance of an adequate evaluation of the findings of the physical examination of the abdomen in acute abdominal lesions. Despite the fact that "abdomen" means hidden, it is astounding how accurate diagnoses can be when proper attention and

significance are accorded the history, inspection of the abdomen, palpation, percussion, auscultation, and the roentgenologic findings in acute abdominal disorders. With improved diagnosis, and mindful of the conditions which can be remedied by operative intervention, as well as of the shortcomings of the surgeon's art, a more conservative policy in dealing with acute abdominal afflictions will probably become generally apparent. The frequent employment of suction to prevent and combat distension which so commonly attends acute introperitoneal lesions, widens the scope of conservative management. We must critically examine ourselves and our therapeutic remedial measures lest we arrogate to ourselves, or attribute to them, credit which neither we nor they deserve.

DR. VERNON C. DAVID (Chicago, Ill.).—I greatly enjoyed Professor Giertz's remarks, and his statements, of course, reflect a great deal of very practical experience in this field.

It seems to me, in a simple way of looking at it, that one of the most important things about operation for peritonitis is to close a continuing contamination from any source within the peritoneum. Once that is done, the main object is obtained. It can be shown very easily, experimentally, that the exudate, is really a protective mechanism, and that this exudate really prevents absorption of toxins as well as bacteria from the peritoneal cavity.

One of the important considerations about the mortality in peritonitis concerns itself with the occurrence of ileus. The development of ileus can be very little interfered with, or very little controlled by operative procedures, except those which close the source of contamination, because most of the cases of ileus result primarily from damage to the bowel wall itself by inflammation with resulting loss of peristalsis, and the main thing that can be done after such a mechanism has been established is to keep the intestinal tract as free as possible by continuous suction or other means embodying that principle.

It is a well known fact, for instance, that when a bowel is brought out onto the abdominal wall for ileostomy or colostomy, it takes only a few hours before the inflammation of that loop causes the loss of all its peristaltic activity, but when that inflammation is controlled, the bowel again takes on its functions, and I believe personally the same thing holds true in regard to the formation of ileus as in most cases of peritonitis.

DR. RUDOLPH MATAS (New Orleans, La.).—I cannot see this discussion come to a close without a note of personal appreciation of the distinguished speaker, Professor Giertz and his Swedish colleagues. Those of us who have had the good fortune to visit the hospitals and medical institutions of Stockholm will always hold a delightful recollection of the unfailing courtesy and generous hospitality of the master surgeons of that city, whom he so fittingly represents.

No one who has attended the surgical clinics of Stockholm, Upsala and Lund can fail to be impressed with the great ability, conscientious thoroughness and alertness for every advance, that characterize the Swedish School of Surgery and that make its contributions to surgical progress and literature so highly esteemed by the surgical world. It is, therefore, especially gratifying to welcome Professor Giertz, and to renew here, as on a previous occasion, the cordiality of our greetings to an honored guest.

In the paper we have just heard, Professor Giertz has given us the results of his ripe and varied experience in the prevention and treatment of peritonitis, a subject which in its many and varied etiologic aspects continues to

furnish perennial material for profitable discussion. His conclusions fully confirm what is generally agreed, that once a fully developed septic peritonitis is established, we are dealing with one of the greatest causes of surgical mortality. We are also generally agreed that the great advances made in reducing the mortality of peritonitis are due to prevention by earlier diagnosis and prompt surgical removal of the potential or actual causes of peritonitis, which ever they may be, rather than by any measures of treatment adopted after diffuse peritoneal sepsis has asserted itself. We need go no further than the story of appendicitis to confirm these generalizations. Doctor Torek's picture of appendicitis, as it appeared to us 40 years ago and as we see it now, especially appeals to me as a contemporary who has lived through the same experience. It may be truly said that for nearly two decades after Fitz had identified the appendix as the chief cause of peritonitis and its complications, we rarely, if ever, operated for appendicitis as a strictly intra-appendicular disease; it was always after perforation and gangrene had infected the peritoneum and caused either a localized suppuration or a generalized peritoneal invasion with all its disastrous consequences. Trust in medical treatment and the fear of postoperative complications invariably delayed the operation long after a preventive or timely appendectomy could be performed. The best that could be expected was a well walled abscess which could be drained with or without the extirpation of the appendix, often leaving protracted fecal fistulae and disabling ventral herniae. The diffuse suppurations, complicated by migratory abscesses, paralytic ileus with uncontrollable vomiting of duodenojejunal contents, were common and the yellow fever type of appendicitis, caused by portal thrombophlebitis, with typical black vomit and jaundice (now practically unknown), was not rare. Bold attempts at free peritoneal irrigation with multiple drains only hastened the fatal termination. No wonder that under these tragic circumstances, all aggressive surgery was abandoned and the old classic treatment of peritonitis by absolute gastro-intestinal immobilization with opium, starvation and rectal drips, popularized by J. D. Ochsner, came into vogue, leaving to surgery only the task of draining localized suppurations.

This method at least tended to arrest the spread of the infection and yielded better results and was less discomfiting to the surgeon and his reputation.

Now, all this has changed. Thanks to the intense, nationwide campaigns conducted against the appendix—day in and day out—by medical societies, popular lectures, the lay press, radio talks and by other innumerable agencies for the diffusion of medical information, the public at large has been thoroughly informed of the dangers of delayed operations and indiscriminate purgation, resulting in the fact that we no longer have to beg patients to have their appendices removed. Now, the mere mention of appendicitis suffices to hasten the alarmed patient to the hospital and the operating table. In this way the number of prophylactic appendectomies have greatly increased and the mortality has unquestionably diminished, despite the contradictory statistics that have appeared on the subject. The fact is that the surgeon today is far more comfortable in the presence of appendicitis and that the tragic specter of septic appendicular peritonitis is fast retreating into the shadows of a grim past, to be replaced by the smiling faces of countless convalescent aseptic appendectomized patients. As in all popular educational campaigns intended to warn the public against avoidable dangers, an alarm is created which is only too frequently abused. But while I am unconditionally opposed to any and all operations performed without a reasonable foundation, I would rather see a barrel full of normal appendices removed

PERITONITIS

through honest error, than see a single avoidable death caused by neglect of timely surgical intervention. While hailing the advent of a new era of prophylactic appendectomies, I am not blind to the fact that, unfortunately in too many instances, the first intimation of appendiceal mischief coincides with a perforation and peritoneal invasion. When this happens, even an immediate operation will disclose that peritoneal infection has occurred and that the door to septic, secondary abdominal complications has been opened. The extirpation of the appendix and exclusion of the primary focus undoubtedly improve the patient's chances, but when widespread infection has occurred, the old tragic picture of diffuse peritoneal sepsis is revived. Then a new chapter of anxious complications begins which, though gloomy, is not as hopeless as in the past, and still permits the display of lifesaving resources not available, or thought of, until relatively recent years and that often will tide the patient over a seemingly fatal crisis.

In referring to great improvements in the treatment of the postoperative complications, the speaker had in mind at least two contributions which have proved of the greatest value in dealing with adynamic or paralytic ileus—one of the most frequent and formidable manifestations of peritoneal infection.

First: the relief of the uncontrollable and exhausting regurgitant vomiting by the method of continuous drainage of the gastro-intestinal contents through the nasopharynx, and allowed to remain *in situ* as long as the regurgitation of the gastro-duodenal contents continues, thus permitting unrestricted drinking of water or other refreshing fluids *per os*, while the drainage is going on automatically. The stomach in the meantime undergoes frequent lavage, while gases and noxious gastro-intestinal secretions are being continuously and unconsciously evacuated. The duodenal tube here acts as an artificial anus, *per vias naturales*, and effectively prevents dilatation and autocompression of the stomach and upper gastro-intestinal loop.

Second: The continuous infusion of dextrose and salt solution by the intravenous drip (phleboclysis), which provides against dehydration, starvation, dechlorination and arterial hypotension while permitting medication with cardiovascular stimulants, and alternating transfusions of whole or citrated blood as may be indicated to reinforce a failing heart and circulation.

These two procedures which were first introduced and adopted by the speaker 23 years ago, have been fully described (Transactions Am. Surg. Assn., 41, 468-491, 1923; ANNALS OF SURGERY, 79, 643-661, May, 1924) and have since come into general use—more or less modified and under different names. These two methods alone, when combined with the free use of morphia, have often sufficed to tide the patients over a dangerous crisis, giving the natural defenses a chance to assert themselves in restricting the spread of the infection and in restoring the normal balance of gastro-intestinal function. Jejunostomy remains, none the less, a supplementary measure of most decisive and lifesaving importance when performed at the proper time and in the proper way, before the patient's vitality has been completely exhausted.

SUMMARY.—(1) While the number of operations for appendicitis have greatly increased, the mortality of the operation has very notably diminished. The lowered mortality is due chiefly to the general acceptance, by the public and the profession, of the principle of early prophylactic operation in the intra-appendicular stage of the disease and before peritoneal contamination has occurred.

(2) The very great improvement in the treatment of the postoperative complications, when peritoneal contamination and infection has already occurred.

THE PREVENTION OF PERITONEAL ADHESIONS BY PAPAIN

A CLINICAL STUDY

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ALTHOUGH *fibrinous* peritoneal adhesions are in most instances protective and therefore desirable, especially in the presence of peritoneal infection, the development and persistence of *fibrous* adhesions are often distinct menaces to the comfort, health, and life of a patient. Whether intra-abdominal adhesions are the result of mechanical, thermic, chemical, or bacterial trauma to the peritoneum, they are generally directly proportionate to the degree, extent, and persistence of the peritoneal injury; therefore, the adhesions following bacterial trauma are usually more marked than those resulting from the less persistent traumatizing mechanisms. Whereas the fibrinous, useful serosal adhesions accompanying peritoneal infection usually disappear after the subsidence of the bacterial invasion, occasionally they persist and become transformed into fibrous adhesions. Infrequently, when damage to the peritoneum is not associated with infection, fibrinous adhesions which have served little or no purpose also become organized and may produce disturbances in intestinal motility. Normally, after the subsidence of the peritoneal infection the proteolytic ferment derived from leukocytes in the peritoneal exudate causes the fibrinous peritoneal adhesions to disappear by a process of autolysis. The reason for the failure in some cases of the normal disappearance of the fibrinous adhesions is not known, but probably in such individuals there exists an abnormal tendency toward the development of fibrous tissue, *i.e.*, "keloid tendency" or "adhesion diathesis."

As peritoneal adhesions are the result of trauma to the serosa, it is imperative that the surgeon minimize the trauma as much as possible by avoiding mechanical injury, cooling and dehydration of the peritoneum during the operation, chemical irritation, and the introduction of microorganisms from without or from the viscera. Whereas the necessity of observing these principles is obvious and, by so doing, the incidence of adhesions can be materially decreased, infection is sometimes already present and, furthermore, considerable peritoneal mechanical trauma may be an unavoidable accompaniment of the operative procedure. In such instances, relatively little can be done to prevent the formation of adhesions, which, as a matter of fact, are desirable and protective. In those individuals in whom the adhesions persist, become organized, and produce disturbances in intestinal motility, subsequent operations become necessary in order to divide the adhesions. Meticulous care during the operative division of the bands both as regards the minimizing of mechanical trauma and the prevention of cooling and infection can

never be supplanted by other measures to decrease the incidence of adhesions. There are, however, cases in which some supplementary agent is necessary, because too frequently in spite of minimal trauma, adhesions recur, particularly in those individuals with "adhesion diathesis" or "keloid tendency."

In a previous publication,¹ to which the reader is referred, a critique of the efficacy of the variously employed substances used to prevent the formation and reformation of adhesions is given. This report also contains the results of experimental observations concerning the effects of papain and trypsin in the prevention of the formation and reformation of peritoneal adhesions. These extraneous ferments were used for the purpose of supplementing a presumably insufficient amount of normal proteolytic enzyme. In a control group of animals adhesions reformed following their division in 100 per cent of instances. If saline solution was introduced into the peritoneal cavity following the division of adhesions, adhesions reformed in 86 per cent. If trypsin solution was introduced following the division of adhesions, they reformed in 57 per cent, whereas if papain solution was used, adhesions reformed in only 9 per cent. It was evident from this investigation that papain solution was more efficacious in preventing the reformation of adhesions following their division than either saline solution or trypsin. Although trypsin is a normal proteolytic ferment of the body and although it would seem that a normal ferment would be most efficient, the relatively poor results obtained by the use of trypsin solution are probably due to the fact that the tryptic activity was neutralized by antitrypsin which is normally found in the body. In corroboration of this Walton² showed that trypsin solution when placed in the peritoneal cavity rapidly loses its activity, but that papain remains active even after long periods of time and that its activity is not decreased by the addition of serum.

In addition to animal experiments parallel clinical observations have been made concerning the effect of papain in preventing serosal adhesions, and the present investigation is based upon an analysis of 231 cases, including the authors' cases, which have been treated by a total of 22 surgeons besides ourselves.* Observations by a large number of surgeons should be of more significance than those made by a small group. Although papain was definitely beneficial in the prevention of the reformation of experimentally produced adhesions following their division, it was realized that a prolonged period of observation of clinical cases so treated should be made before any definite conclusions could be drawn concerning its clinical value, because clinically it is not possible, as in the experimental animal, to relaparotomize patients at will in order to determine the presence or absence of adhesions, and because many patients can be perfectly comfortable with adhesions for years and then for no apparent reason develop signs of obstruction, which require reoperation. In the present clinical investigation, a subsequent laparotomy following the use of papain was performed in 37 cases. In most

* The papain used in the investigation was prepared in sterile form and generously supplied by the Parke-Davis Company.

instances the laparotomy was performed for some other lesion. An analysis of these cases is particularly valuable, because it is more comparable to the experimental observations.

In the 231 cases analyzed, the sex was stated in 169 cases, of which 142 (84.1 per cent) were females, and 27 (15.9 per cent) were males (Chart 1).

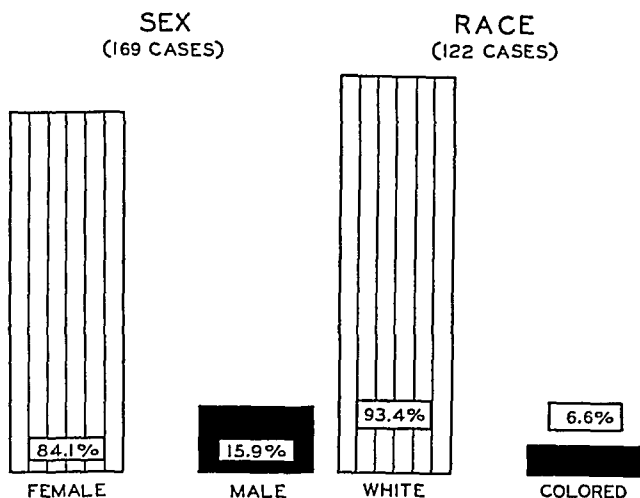


CHART 1.—Showing sex incidence in 169 cases in which it was stated.

CHART 2.—Showing race incidence in 122 cases in which it was indicated.

In 122 in which the race was indicated, 114 (93.4 per cent) were white and eight (6.6 per cent) were colored (Chart 2). In 140 cases in which the age was given, the youngest was four and the oldest 69. One (0.7 per cent) was in the first decade, 14 (10 per cent) were in the second decade, 39 (27.8 per

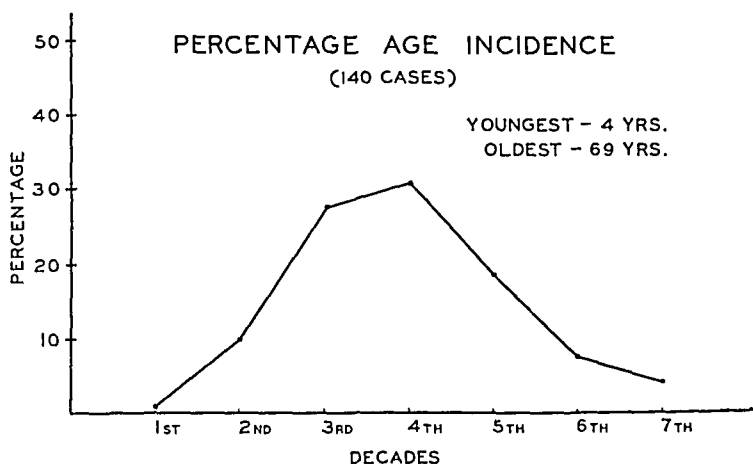


CHART 3.—Showing the age incidence according to decades in 140 cases in which the age was indicated.

cent) in the third decade, 43 (30.7 per cent) in the fourth decade, 26 (18.5 per cent) in the fifth decade, 11 (7.8 per cent) in the sixth decade, and six (4.2 per cent) in the seventh decade (Chart 3). Sixty per cent of the total number of cases were in the third and fourth decades.

In 122 patients in whom previous operations had been done, 317 operations were performed, or an average of two and one-half operations for each

patient. One hundred thirty-two (40.3 per cent) of the entire group of operations were for peritoneal adhesions and intestinal obstruction. As in 42 cases of the entire group the type of operation was not stated, the incidence of operation for adhesions and intestinal obstruction was 46.9 per cent in those in which it was stated. From the large number of operations previously performed for intestinal obstruction and adhesions, it is evident that many of these patients had an "adhesion diathesis." Fifty-seven (17.9 per cent of the entire group and 20.8 per cent of those in whom the type of operation was stated) had had a previous appendectomy. Forty-four (13.7 per cent of the entire group and 16.2 per cent of those in whom the type of operation was stated) had pelvic operations. Of these 44, eight had had a hysterectomy combined with other pelvic procedures, 25 had had some pelvic operation without a hysterectomy, and 11 had had cesarean section. Twenty-

PREVIOUS OPERATIONS
(317 OPERATIONS ON 122 PATIENTS)

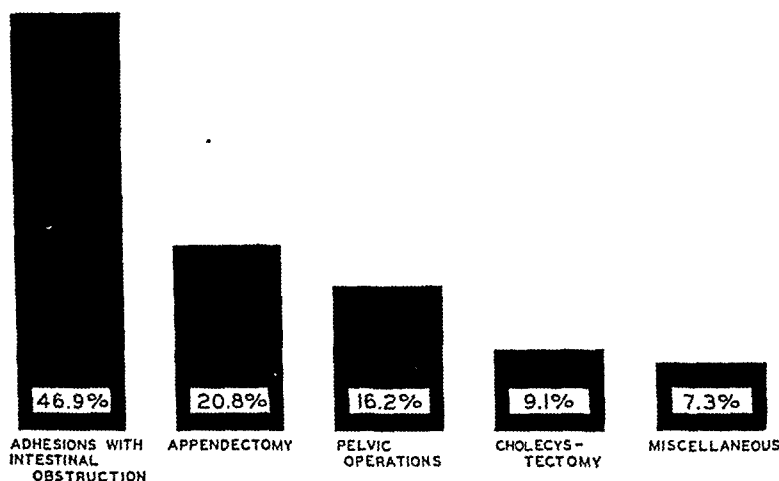


CHART 4.—Showing the percentage incidence of types of 317 operations performed on 122 patients in which papain was used.

five cases (8.8 per cent of the entire group and 9.1 per cent of the cases in which the operation was stated) had had cholecystectomy; two of these had had choledochotomies. Ten (3.1 per cent of the entire group) had had hernioplasties, six (1.8 per cent of the entire group) had had enterostomies, and one (0.3 per cent) had had an intestinal resection (Chart 4).

As mentioned above, a total of 317 operations was performed on 122 patients, an average of two and one-half operations for each patient. The greatest number of operations on one individual was 22, the smallest number was one. Fifty-five (45 per cent) had only one operation; 34 (27.8 per cent) two operations; ten (8.1 per cent) three operations; eight (6.5 per cent) four operations; five (4 per cent) five operations; three (2.4 per cent) six operations; two (1.6 per cent) eight operations; one (0.8 per cent) 18 operations, and one (0.8 per cent) 22 operations. Four per cent had nine or more operations; 12 per cent five or more; 26.6 per cent three or more, and 54.4 per cent two or more operations prior to the operation at which the papain was introduced into the peritoneal cavity (Chart 5).

Theoretically, papain solution might be used either for the prevention of the formation of adhesions at the original operation in an individual in whom there had been considerable trauma, but probably the best results and certainly the best evaluation is to be obtained in those cases in which adhesions have formed and in which the prevention of the reformation of adhesions

NUMBER OF OPERATIONS PRIOR TO USE OF PAPAIN

(317 OPERATIONS ON 122 PATIENTS)

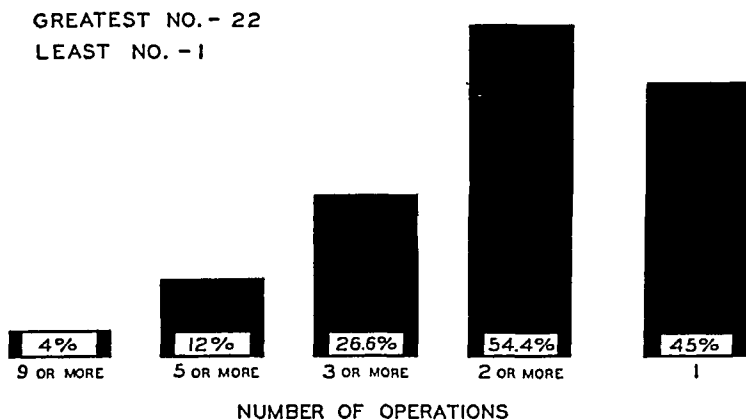


CHART 5.—Showing the number of previous operations performed on 122 patients.

following their division is desired. In the present clinical investigation, papain was used in 89 per cent of the cases to prevent the reformation of adhesions after their division. In only 11 per cent of the instances was papain used to prevent the formation of adhesions at the original operation (Chart 6).

INDICATION FOR USE OF PAPAIN EXTENT OF ADHESIONS BEFORE DIVISION AND USE OF PAPAIN

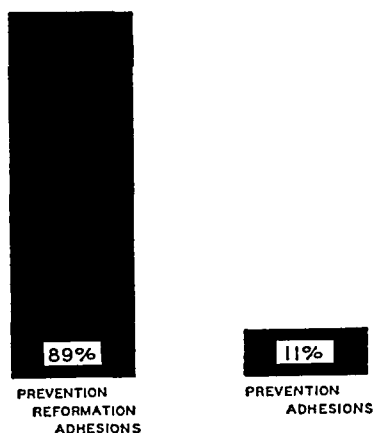


CHART 6.—Showing the indications for use of papain.

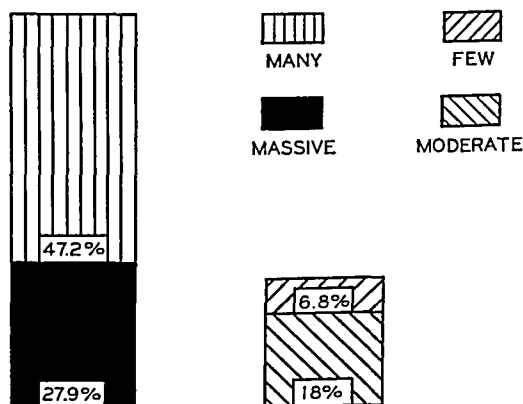


CHART 7.—Showing comparatively the extent of adhesions present before division and the use of papain.

In 161 of the observations a statement was made concerning the degree and the extent of the adhesions before their division at the time of operation. In 11 (6.8 per cent) the adhesions were few in number, in 29 (18 per cent)

they were moderate, giving a total of approximately 25 per cent in which the adhesions were not extensive before their division. In 76 (47.2 per cent) there were many adhesions and in 45 (27.9 per cent) the adhesions were massive, a total of approximately 75 per cent of extensive adhesions before their division (Chart 7).

In 109 cases collateral procedures besides the division of adhesions were performed. In all, 125 operations were done. Fifty-six (44.8 per cent) had pelvic operations, of which 44 (35.2 per cent) had pelvic operations without hysterectomy, and 12 (9.6 per cent) had pelvic operation combined with hysterectomy. Twenty-two (17.6 per cent) had an appendectomy; in 14 (11.2 per cent) a first stage of abdominal perineal resection of the rectum was done at the time of the papain introduction; in 12 (9.56 per cent) a cholecystectomy was done, and in 11 (8.8 per cent) a hernioplasty was done.

COLLATERAL SURGICAL PROCEDURES

(125 OPERATIONS IN 109 CASES)

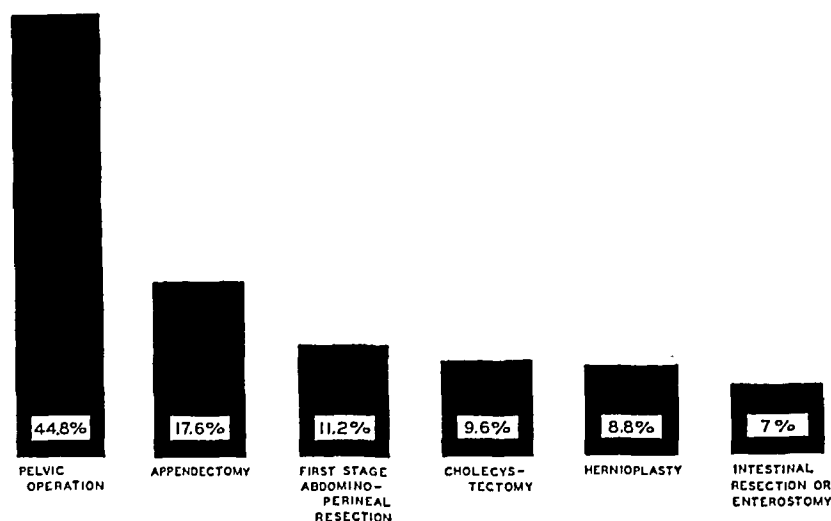


CHART 8.—Showing comparatively the types of the 125 collateral operations performed on patients at the time adhesions were divided and papain used.

In four (3.5 per cent) resection of the bowel and in four (3.5 per cent) enterostomy was done. In one resection of echinococcus cyst of the liver and in one cecopexy was done (Chart 8).

The period of observation after the division of adhesions and use of papain was stated in 190 cases. In 11 (5.7 per cent) it was between three and six months, in 17 (8.9 per cent) six months, in five (2.6 per cent) nine months, in 26 (13.6 per cent) one year, giving a total 17.2 per cent in which the observation was a year or less. In 21 (11 per cent) the observation was for one and one-half years, in 37 (19.4 per cent) for two years, in 21 (11 per cent) for two and one-half years, in 20 (10.5 per cent) for three years, in 14 (7.3 per cent) for three and one-half years, in 12 (6.3 per cent) for four years, in two (1 per cent) for four and one-half years, in three (1.5 per cent) for five years, and in one (0.5 per cent) for five and one-half years. Of the entire group, 9.3 per cent had been observed for four years or longer, 27.1 per cent for three years or longer, 57.5 per cent for two years

or longer, 82.1 per cent one year or longer, and only 17.2 per cent had been observed less than a year (Chart 9).

The mortality rate following the use of papain in the 231 cases in which it was used was 1.8 per cent, four deaths in the entire group (Chart 10). One of these patients died of acute gastric dilatation two weeks postoperatively. At postmortem no adhesions were found. In another patient death resulted from perforation of the bowel and inflammation of the ileum, and at postmortem many old adhesions were found. In the other two cases no clinical cause of death or autopsy findings were given.

In a total of 224 cases in which the results were given, in 186 (83 per cent) the results were classified as excellent. In an additional 13 (5.8 per cent) the results were classified as good, giving a total of 199 (88.8 per cent)

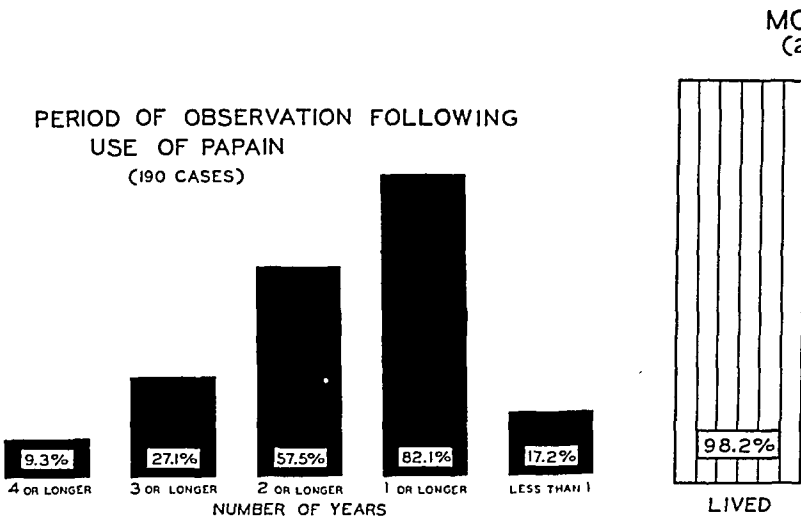


CHART 9.—Showing the percentage of patients who were observed for varying periods following the use of papain.

MORTALITY
(231 CASES)

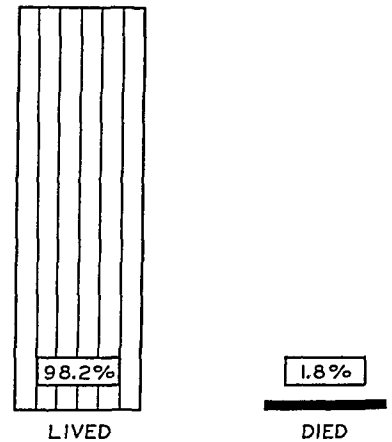


CHART 10.—Showing the mortality in cases in which papain was used.

as satisfactory results. In 17 (7.5 per cent) the results were classified as fair, and in eight (3.5 per cent) the results were classified as poor, giving a total of fair and poor in 11 per cent (Chart 11). The incidence of 88.8 per cent of satisfactory results is particularly interesting, because in the experimental investigation with papain performed approximately five years ago it was found that papain prevented the reformation of adhesions in 91 per cent of observations and that in only 9 per cent were there definite and dense adhesions present (Chart 12).

There were 37 cases in which subsequent operations were performed and in which the presence or absence of adhesions could be determined. Obviously the results in this group are more significant, because, even though a patient may be clinically free from symptoms, it is no indication that adhesions have not reformed; but the fact that 82 per cent of the patients had been observed for a year or longer and 57 per cent two years or longer and remained clinically well is a fairly good indication that probably most of them developed no adhesions. In the 37 cases in which a subsequent operation was done, largely for the removal of other viscera, in two (5.4 per cent) there was a reformation of many adhesions. In one of these the patient had

PAPAIN PREVENTION OF PERITONEAL ADHESIONS

had an evisceration following the operation in which papain was used and which undoubtedly had a great deal to do with the reformation of the many adhesions. In 13 (35.1 per cent) there were some few adhesions present.

CLINICAL RESULTS FOLLOWING USE OF PAPAIN

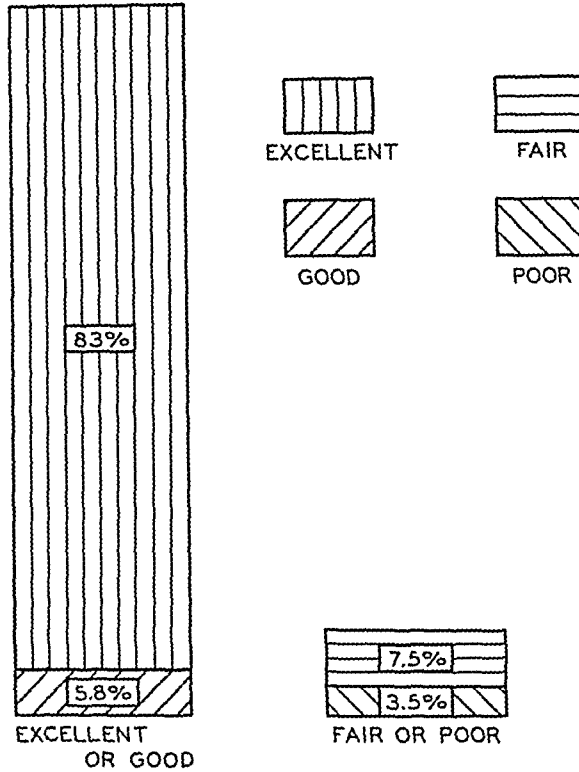


CHART 11.—Showing the incidence of the clinical results following the use of papain.

COMPARISON OF PAPAIN RESULTS

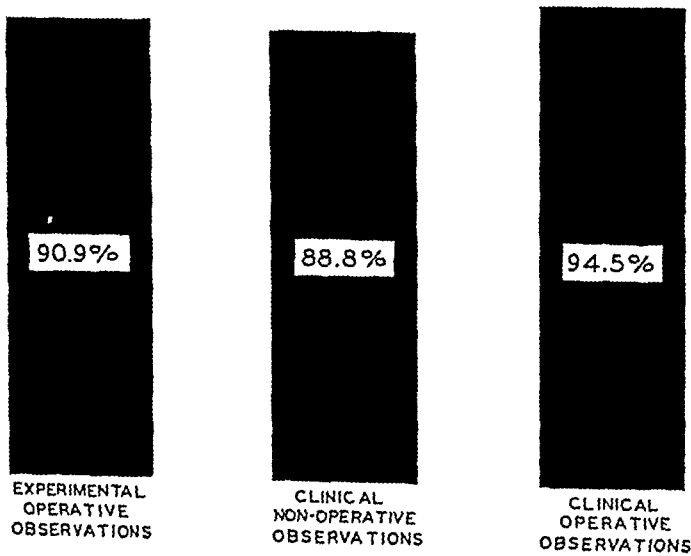


CHART 12.—Showing the findings at operations performed subsequent to the use of papain.

In ten of these (24 per cent of the whole) there was a statement made by the surgeon that the adhesions were considerably less than at the previous operation. In the three additional ones no statement was made as to whether

the adhesions were more or less than were found previously. In 22 of the entire group (59.4 per cent) there were no adhesions in the abdomen, although many and massive adhesions had been present prior to their division and to the use of papain. Thus, in 94.5 per cent papain was of distinct benefit in preventing or minimizing adhesions (Chart 13).

COMMENT.—Although it is extremely difficult to evaluate procedures in clinical cases and observation over a long period of time is necessary, the analysis of 231 cases studied in this investigation seems to justify the as-

FINDINGS AT SUBSEQUENT OPERATIONS (37 CASES)

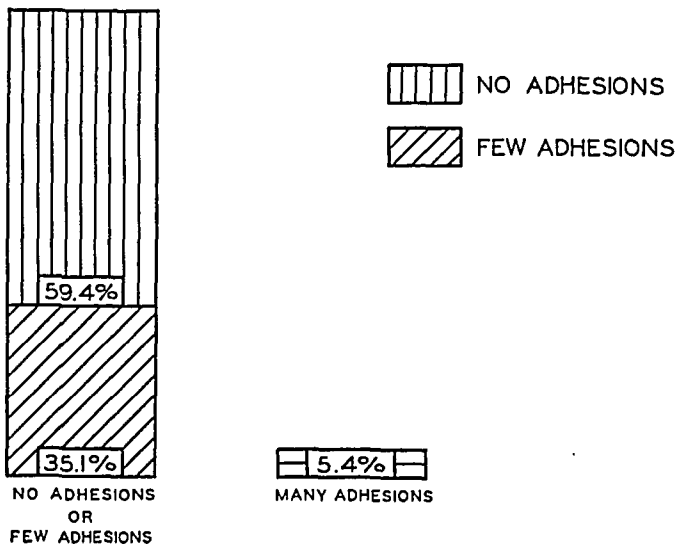


CHART 13.—Showing the close parallelism of satisfactory results observed in the experimental operative observations, the clinical nonoperative observations, and the clinical operative observations.

sumption that the introduction of papain solution into the peritoneal cavity following the division of adhesions is of value in preventing the reformation of adhesions. This is particularly evident when one considers that of 122 cases in which it was stated, 317 previous operations before the operation for the division of adhesions had been done, and especially because 46.9 per cent of these operations were for adhesions with intestinal obstruction, indicating that many of the patients were individuals with "keloid tendency" or "adhesion diathesis." The fact, too, that 54.4 per cent of these individuals had had two or more operations, 26.6 per cent had had three or more operations, and 12 per cent had had five or more operations supports this contention. In over three-fourths of the cases the adhesions at the time of the division were classified by the operating surgeon as many or massive. In addition to the division of the adhesions which in itself necessitated a certain amount of operative trauma and in many instances caused large areas of peritoneal denudation, collateral procedures were performed in 109 cases, which also added to the peritoneal trauma and predisposed to the reformation of adhesions.

Although many years must elapse before one can truly evaluate any substance as regards its ability to prevent the reformation of adhesions, it is

significant that in the present investigation, over one-half of the cases, 57.5 per cent, were observed two years or longer, over three-fourth of the cases (82.1 per cent) were observed one year or longer, over one-fourth (27.1 per cent) were observed three years or longer, and only 17.2 per cent were observed less than one year. Obviously a long period of observation and on a much larger group of cases is necessary before final conclusions concerning the value of papain can be drawn.

The low mortality rate, 1.8 per cent, in the entire group of 231 cases in which there was considerable operative manipulation, is an indication that the papain solution per se is harmless. In our own personal experience we have never observed any untoward results following its use, and we are convinced that it can be used without danger. The question has been raised a number of times whether papain should be used in the presence of infection, as in this way the digestion of the desirable and protective adhesions might be favored. Although the digestion of adhesions in the presence of infection is indeed undesirable, we believe that the use of papain in infection is harmless because the peritoneal trauma caused by the invasion of microorganisms lasts for a longer period of time than does the activity of the papain. In our own clinic we have limited the use of papain to those cases in which the prevention of the reformation of adhesions is desired and with few exceptions have not used it for the prevention of the formation of adhesions at original operation, because from an investigative standpoint the results obtained in the former group are more significant than those obtained in the latter group. We have limited the use of papain to the former, because one can never be certain that any individual who has had considerable intraperitoneal manipulation will develop adhesions. Of much more significance, however, is the prevention of the reformation of adhesions in the individual with adhesions which developed following an antecedent operation, because many of these patients have an "adhesion diathesis." If, however, papain is efficacious in preventing the reformation of adhesions, there is no reason why it should not be used in cases in which at the original operation there is considerable intraperitoneal trauma and in which the prevention of the reformation of adhesions is desired.

In our original investigations and in the earlier clinical cases, the papain was prepared, using saline as a diluent. Relatively recently, on the basis of additional experimental observations, we have been using Hartmann's combined physiologic solution as a diluent and believe that our results are better than those obtained with saline alone. Bogart³ is of the opinion that a solution of 0.08 of 1 per cent of sodium citrate in distilled water is the diluent of choice. In our investigations citrate solution was not as efficacious as Hartmann's solution.

Whereas papain solution in the experimental animal is efficacious in dilutions as high as 1 to 40,000 and 1 to 50,000, in our recent clinical investigations we have been using dilutions of 1 to 20,000. As papain loses its efficacy very rapidly when in solution, it is imperative that the papain be kept in a dry form and that the solution be prepared immediately before its use. As

the sterile papain is supplied in 25 mg. ampules, it has been our custom to dissolve the contents of two ampules in 1,000 cc. of physiologic Hartmann's solution. This is done as follows: Fifty milligrams of papain are used for 1,000 cc. and prepared by emptying the 50 mg. of papain into a sterile mortar and adding a small amount of sterile Hartmann's solution. By the use of the mortar and a pestle the solution of the papain is greatly favored. A small amount of Hartmann's solution is then used to rinse out the vial in which it was originally contained and also to rinse out the mortar. After the division of all the peritoneal adhesions and just prior to putting in the last serosal suture, a catheter is introduced into the peritoneal cavity to which a funnel is attached. As much fluid is introduced into the peritoneal cavity as is possible. In the present series the amount varied from 250 to 1,500 cc., the average amount being 1,095 cc. In most instances a liter was introduced. Immediately after the introduction of as much of the papain solution as the peritoneal cavity will hold, the peritoneal suture is tied, keeping the solution in the cavity. Although theoretically there might be some danger of digestion of catgut suture material, we have not seen any such results.

Eighty-eight and eight-tenths per cent of excellent and good clinical results coincide well with results obtained by Bogart, who in 30 clinical cases had good results in 86.6 per cent. Our results are even more significant because in one of the eight in which poor results were obtained, the continuance of symptoms was probably due to the persistence of a chronic duodenal ileus, while in another instance, evisceration occurred following the use of the papain and possibly accounted for the production of many subsequent adhesions. In one of the 17 cases in which fair results were obtained, an echinococcus cyst of the liver was found at the original operation, and this may have been responsible for the lack of relief following the use of papain in that case.

Of greatest significance in this present study is the close correlation between the good results obtained in the experimental work done five years ago, the percentage of cases in which clinical relief followed the employment of papain, and the frequency with which an absence of adhesions was demonstrated at laparotomy subsequent to the use of papain. In the experimental animal, prevention of reformation of adhesions following their division was possible in 90.89 per cent. In the present investigation excellent or good clinical results were obtained following the division of adhesions and use of papain in 88.8 per cent. In the 37 cases in which a subsequent operation was performed following the division of adhesions and the introduction of papain, no adhesions were found in 59.4 per cent; a few adhesions were found in 35.1 per cent; in only 5.4 per cent (two cases) were the adhesions as great as they were before the use of papain and in one of these two cases evisceration had occurred following the operation and probably accounted for the recurrence of the massive adhesions (Charts 12 and 13). It would seem, therefore, that in approximately 94 per cent of instances papain had been efficacious in either preventing or definitely diminishing the number of adhesions. The fact that the results obtained with regard to the relief of

clinical manifestations and the demonstrated prevention of reformation or diminution in the number of adhesions in the reoperated cases corresponds so closely with the results obtained in the experimental animal as regards the prevention of the reformation of adhesions made these results more significant. It is of interest also that in Bogart's series good clinical results were obtained in 86.6 per cent of the cases.

SUMMARY

Two hundred thirty-one clinical cases are reported in which papain solution was used to prevent the reformation or initial formation of peritoneal adhesions. Many of these patients were considered to have a "keloid tendency" or "adhesion diathesis," because 122 patients in the group had had previous operations and in 46.9 per cent of instances in which the type of operation was stated, it had been for adhesions and intestinal obstruction. The period of observation following the division of adhesions and use of papain was one year or longer in 82.1 per cent. In a total of 224 patients in which the clinical results were given the results were classified as excellent in 186 (83 per cent) and in an additional 13 (5.8 per cent) the results were classified as good, giving a total of 199 cases (88.8 per cent) in which satisfactory results were observed. In 17 cases (7.5 per cent) the results were classified as fair and in eight (3.5 per cent) the results were classified as poor, giving a total of fair and poor results in 11 per cent.

Thirty-seven cases were relaparotomized following the use of papain. In 22 (59.4 per cent) of these there were no adhesions in the abdomen although many and massive adhesions had been present prior to their division and to the use of papain; in 13 (35.1 per cent) there were some few adhesions present, but many less than before the use of papain, whereas in two (5.4 per cent) there was a reformation of many adhesions. There is a close correlation between the clinical results (88.8 per cent satisfactory), the observations made at operations subsequent to the use of papain (94.5 per cent satisfactory results), and the experimental observations (90.9 per cent satisfactory results) done five years ago. None of the four deaths (1.8 per cent) which occurred in this series of 231 cases could be attributed to the use of the papain solution.

NOTE.—We wish to express our appreciation of the following men who have assisted in this clinical investigation by furnishing reports of cases in which they have used papain for the prevention of peritoneal adhesions: Charles H. Arnold, William L. Bendel, W. E. Bird, Leon M. Bogart, Aza W. Collins, John B. Deaver, John F. Denton, A. R. Dickson, James Q. Graves, Donald Guthrie, E. S. Hicks, W. Kernan Irwin, Walter C. Jones, Morris Joseph, Joseph E. J. King, George V. Lewis, S. Mirabella, Damon P. Pfeiffer, A. A. Skemp, John G. Snelling, Benjamin W. Ward, and George W. Wright.

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DELAYED WOUND HEALING FOLLOWING NEPHRECTOMY FOR TUBERCULOSIS

ANALYSIS OF CAUSE

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IT IS a well known fact that the lumbar incision used in the removal of a tuberculous kidney in a certain proportion of cases heals less rapidly than nephrectomy wounds in which the kidney shows no evidence of tuberculosis. The disturbance in the wound healing in these tuberculous cases varies from an extensive breaking down of the apparently healed wound to the formation of one or more fistulae. The cause of this peculiar behavior of the wounds is apparently a local tuberculous condition, though in only a small percentage of the cases does the granulation tissue removed from these wounds show typical tubercle formation.

To date, no one has found a method of preventing this complication which may lead to great inconvenience for the patient occasioned by prolonged discharge and more or less incapacitation. Some of these wounds remain open and discharge for years, so that the individuals are under the doctor's care for a very long time. The exact cause of this type of wound infection has as yet not been recognized, though one of us¹ has repeatedly called attention to the possibility that the lumbar muscular wound becomes infected by tubercle bacilli, which have been thrown into the circulation by the manipulations incidental to the nephrectomy. An infrequent cause of such wound infections is the gross contamination of the wound by spilling, which, however, does not regularly produce the typical slow healing lumbar wounds. The usual explanation found in the literature for these slowly healing wounds attributes them to the remaining tuberculous ureter and generally these infected wounds and tuberculous ureter fistulae are considered synonymous.

The object of this paper is to call attention to the fact that in a large series of cases we have been able to show definitely that the diseased ureter has nothing to do with the slow healing and the tuberculous infection of the muscular wound, but that the essential underlying causation is a traumatic bacteriemia induced by the operator, which leads to a deposition of tubercle bacilli in the vascular muscle wound and in the traumatized deeper tissues. Only occasionally is the wound infection due to gross spilling of pus containing tubercle bacilli, the result of an accidental rupture either of an abscess in a calix, of the pelvis or of the ureter during the delivery of the tuberculous kidney. In a study of 281 cases, we have found no evidence of tuberculosis of the perirenal fat, such as has been described by Legueu, except in the sclerosed perinephric fat, which is adherent to the kidney in long standing

cases. In the early cases, before the perinephric fat has been grossly involved, we have, as yet, never detected evidence of tuberculosis in the microscopic study of this tissue, and therefore cannot consider it an underlying cause of the unfortunate accident and clinical picture.

For many years I (E. B.), have been deeply interested in the problem of bacteriemia caused by trauma to the patient from within, or from without, by instruments or operations. Cases have been observed in which the passage of biliary and kidney calculi have been associated with chills, a sharp rise in temperature and transitory bacteriemia. Similar cases have been seen after urethral or ureteral instrumentation. Other writers, including Winter, Schottmueller, Buschke, Dudgeon, Mitchener, etc., have called attention to traumatic bacteriemia. More recently Seifert, in 1925, reviewed most of the work and found that operations in an infected terrain frequently led to bacteriemias, especially in early infections and in vascular areas and that the rougher the manipulations and the longer the operation, the more frequent were the bacteriemias. In *Staphylococcus aureus* and *albus* infections, such bacteriemias developed in 54 per cent of 55 cases; in *streptococcus* (*erysip- elitus*) infections, bacteriemia developed in 30 per cent of 11 cases; in colon bacillus infections, bacteriemia developed in 25 per cent of 11 cases. Interesting to relate, he found in non-infected patients in aseptic operative fields (*e.g.*, goiter operations) transitory, postoperative bacteriemias. The clinical observation has been made by many that following operations upon tuberculous foci, especially in tuberculosis of the generative organs and the kidneys, occasionally a diffuse miliary tuberculosis develops with tuberculous meningitis as the outstanding symptom. The postoperative course of many of these cases is accompanied by spiking temperatures typical of a sepsis and some, perhaps the majority, gradually become normal, whereas the others die, having developed the definite and fatal signs of tuberculous dissemination. In the first group, apparently the bacteriemia was transitory, as is frequently the case with the coccal and colon group.

Experience has shown that it is particularly difficult to pick up the tubercle bacillus in the blood stream. In well over 30 patients suffering from renal tuberculosis, we (E. B., and the late Dr. Eugene Bernstein) injected the blood taken just before and just after the nephrectomy into guinea-pigs, and in three cases were able to produce tuberculosis. Graf called attention to tubercle bacilli in the blood following operations upon tuberculous foci. Seifert emphasizes the great difficulty of this research, which is explained by A. Calmette by the fact that blood or serum is liable to be toxic to guinea-pigs in amounts equal to 8 cc. In view of the postoperative incidence of miliary tuberculosis following nephrectomy of a tuberculous kidney, J. Israel suggested that the trauma of the operation probably led to dissemination of the bacilli. Zuckerkandl called attention to a similar dissemination after curettage of a tuberculous wound. H. Wildbolz and A. Westerborn called attention to the dissemination and production of miliary tuberculosis by cys-

toscopy and Kearns reported similar dissemination following retrograde pyelography.

Although the clinical evidence of a sepsis due to traumatic dissemination of tubercle bacilli during operations is overwhelming, the work of Eugene Bernstein on the inoculation of guinea-pigs with the blood of patients before and after nephrectomy for tuberculosis is, as far as I can gather from the literature, the outstanding laboratory evidence of the phenomenon under discussion.

There is rather general agreement as to the frequency of disturbed healing in the lumbar wound in all clinics where many cases of tuberculosis come to nephrectomy. Israel in the study of his material and other clinics found 29.4 per cent fistulae still present after six months. Braasch found 43 per cent healed within three months and 87 per cent within one year of operation. Wildbolz in 175 nephrectomies found 44 fistulae, or approximately 25 per cent. In our series of 281 cases, it is imperative that we divide our cases into two groups, those in whom a simple nephrectomy (lumbar) was performed, and those in whom an aseptic nephro-ureterectomy² was effected through two incisions, the typical posterior vascular muscle incision, and the anterior avascular rectus sheath extraperitoneal approach to the ureter. In the first group, there were 243 nephrectomies with 58 wound sinuses or fistulae (23.8 per cent), whereas in the second group there were 38 aseptic nephro-ureterectomies and nine (23.7 per cent) developed lumbar wound sinuses, whereas only three cases developed mild infections in the rectus sheath incision. In one of these the infection of the anterior incision seems to have developed from an ureter stump abscess 26 days following the operation, the wound having closed before this abscess developed. In the second there was gross spilling of infected pus on cutting through the pelvic ureter between the ligatures and in the third case the pelvic ureter was considerably traumatized, as it was very adherent.

In both series of cases the incidence of trouble in the lumbar wound was the same, whether the ureter was removed or not. This observation makes it very clear that the generally accepted explanation, that these lumbar wound fistulae are caused by the tuberculous ureter, is untenable. Moreover, the striking difference between the behavior of the two wounds, the lumbar and the rectus, despite the presence of the tuberculous ureter stump in the anterior, avascular, rectus wound, together with the other evidence submitted, points to but one conclusion; namely, that traumatic, tuberculous bacillema is induced by the operator, and leads to infection and tuberculosis of the rather vascular posterior wound, while the anterior wound, being practically completely avascular, is spared.

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DISCUSSION.—DR. HUGH CABOT (Rochester, Minn.): Doctor Beer referred to the occasional occurrence of miliary tuberculosis. It is a rare complication, but, as he suggests, does occur. One frequently sees (I have no doubt he will recognize them) sharp reactions following nephrectomy. They are characterized by a rise of temperature out of proportion to the rise in pulse, no other symptoms, and no evidence of ordinary infection. I have long regarded them as tuberculin reactions, though I am by no means sure that they are caused only by the toxins and that they are not in fact due to the massage that is inevitable in removing the kidney, and thus to the presence of tubercle bacilli in the circulation. I think this reaction without other infection makes it clear that it is something related to the tuberculous process.

My experience leads me to suggest that patients operated upon in, what we are pleased to call, the early stages of the disease (of course one never sees the early stages of renal tuberculosis; we always see the late stages), in the stage of moderate ulceration of the papilla, often do very badly. Possibly this may be related to the lack of protection which the patient receives from the more chronic process. I do not suggest that we allow a tuberculous kidney to remain until the bladder has become thoroughly infected and damaged, but I do feel that operation upon, what we are pleased to call, the early stages of the disease is not always wise. There is a certain amount of protection developed as the result of the longer development of the lesion.

My own opinion is that most of the persistent sinuses are related to residual tuberculosis, partly in the remaining capsule, and, in the more chronic cases, partly to actual tuberculous nodes lying in the neighborhood of the pedicle. I have had several cases in which I was aware that I had left tuberculous disease, and those patients have developed sinuses. Finally, my own experience over a good many years with the routine use of tuberculin after these operations suggests that it has reduced the incidence of sinus formation more than half.

I should hesitate to adopt, what I take to be, Doctor Beer's suggestion that we abandon the lumbar route and use an anterior approach to these kidneys. I am not at all sure that we should, in fact, remedy the difficulty by that method.

THE RÔLE OF SURGERY IN THE TREATMENT OF ACTINOMYCOSIS

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THIS presentation is in essence a brief recital of the writer's personal experience with the treatment of actinomycosis. The mode of origin of this disease is still an enigma, in that the organisms which are found in the diseased tissues of patients or animals having actinomycosis have not been found elsewhere in nature or even in these same hosts when free from the disease; the causative organism can be grown, to be sure, on artificial culture media. Actinomycosis-like organisms inhabit the mouths of healthy individuals, but in the main they are believed not to be pathogenic. The organism found almost invariably in human cases of actinomycosis is the anaerobic *Actinomyces bovis* which also causes "lumpy-jaw" in cattle. When the mystery of how this organism reaches and sets in motion the series of events which leads to actinomycosis is solved, intelligent prophylactic measures may be devised which may spare men the sufferings and ravages of the disease.

Sites Where Actinomycosis May Occur.—There are essentially three regions in the body where actinomycosis commonly occurs, *viz.*, (1) the head and neck, (2) the thorax, and (3) the abdomen. The usual portal of entry for cervicofacial actinomycosis is believed to be the mouth; for thoracic actinomycosis, aspirated or ingested organisms which lodge in pulmonary tissue or penetrate the esophagus; the usual lodgment of organisms which give rise to abdominal actinomycosis is the ileocecal segment of the intestinal canal.

PATHOLOGY.—Lodgment of the ray fungus, *Actinomyces bovis*, in tissue brings about a granulomatous type of reaction in which the features of an acute as well as chronic infection may be concurrently noted. Immediately about the organism a zone of cellular activity usually occurs in which are present large masses of polymorphonuclear and mononuclear leukocytes, epithelioid cells, and a rich network of young blood vessels. This reaction becomes manifest to the unaided eye as abscess formation, with burrowing pus channels filled with purulent collections containing the yellow, sulphur-like granules of the *Actinomyces* colonies. The vascularity of this granulomatous process is always striking at operation. Hemorrhage from this tissue when curetted away may be alarming, lending the impression that a large blood vessel may have been opened, yet, slight gentle pressure with a gauze pack usually serves to arrest it. Randall, who studied the cases of actinomycosis observed at this hospital up until 1933, points out that the

yellow color of the exudate is due in large part to the presence of pseudo-xanthoma cells rich in lipoids. The *Actinomyces* are nonmobile, but are carried into the surrounding tissues by the macrophages.

Peripheral to this area of necrosis and liquefaction is observed a proliferation of dense connective tissue—an attempt to localize and stop the destructive process. The brawny induration observed clinically in cases of actinomycosis is afforded by this keloid-like proliferation of connective tissue. Central softening and peripheral induration with the suggestion of remarkable vascularity, as imparted by the color of the skin, are the gross features of the actinomycotic process which is about to rupture through the skin. Spontaneous fistulization with discharge of yellowish exudate is not unusual. In man, primary involvement of bone is infrequent and is usually observed as an extension from an adjacent process; in cattle, involvement of the jaw bone is the most frequent initial lesion of true actinomycosis.

The Spread of Actinomycosis.—When the disease is recognizable clinically, the portal of entry ordinarily remains but a conjecture. The proximity of the diseased process to one of the commonly accepted sites of origin of the disease merely suggests it as the portal through which the infection invaded the adjacent structures. Actinomycosis exhibits an extraordinary ability to extend into healthy tissue, leaving no trace of the disease at the site of entry. This is particularly true of abdominal actinomycosis. It is likely that the unexpected finding of isolated actinomycosis in a subphrenic abscess, in the kidney, in the urinary bladder, the female generative organs, in the abdominal wall, or a collection of actinomycotic exudate eroding the lower thoracic or lumbar spine commonly have their origin in actinomycosis which initially found lodgment in the cecum.

Actinomycosis rarely becomes generalized in the sense in which a tumor metastasizes, though instances apparently have, however, occurred to indicate that distal spread by the blood stream does take place. Most of such cases concern the invasion of a pulmonary vein by an actinomycotic process in the lung: its entry into the left heart and its propagation as a thrombus into one of the cerebral vessels, with lodgment in the brain. Jacoby²¹ has reviewed a number of such instances. These cerebral actinomycotic abscesses are sometimes multiple. Similar, but less frequent, spread to liver, spleen, or kidney has also been noted. It is particularly the thoracic and abdominal varieties of actinomycosis which give rise to blood stream invasion. Because of the remarkable invasive features of actinomycosis by which the disease spreads by direct extension, involvement of liver and spleen may occur in either abdominal or thoracic actinomycosis by direct migration without the agency of blood stream metastasis.

There is a fairly large number of instances of isolated actinomycosis of the urinary bladder, the female generative organs, the kidney, and even bone, the origin of which remain uncertain. As was suggested above, undoubtedly some of these may have their origin in so called abdominal actinomycosis,

presumably the residual of an actinomycotic process which migrated out from the intestinal canal.

That actinomycosis may have reached these organs by direct spread from an actinomycotic focus which had its origin elsewhere than in the intestinal canal is a possibility. The instances of isolated actinomycosis of the stomach which have been observed undoubtedly have their origin in the ingestion and direct lodgment of the *Actinomyces* in the stomach.

Extension from cervicofacial actinomycosis may occur into the thorax by way of the supraclavicular fossa; invasion of the cranium through the orbit or by way of the foramina at the base of the skull or by direct erosion of bone have all been observed. The importance of early recognition and adequate treatment of the lesion to obviate these unfortunate occurrences is immediately apparent.

DIAGNOSIS.—That actinomycosis of the thorax or abdomen may not be early identified is obvious; why actinomycosis of the cheek or neck should not be recognized early is difficult to understand. A lesion which may be seen and palpated should suggest invoking aids to affirm or deny the presence of actinomycosis. Mere consideration of the possibility of the lesion goes a long way toward its identification if every such lead is pursued to its logical conclusion.

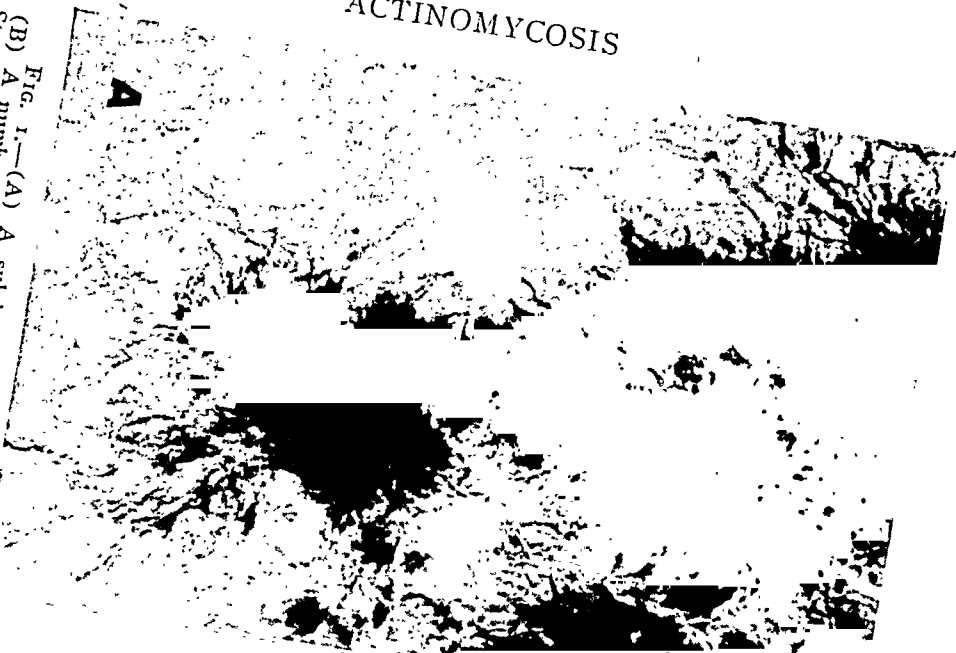
The determination of the actual presence of actinomycosis rests upon bacteriologic means. The exudate recovered from an area of softening by needle aspiration or that obtained from a sinus or recovered by curettement at operation is put out on gauze or placed in water where the granules may be more readily identified. Suspicious looking granules are placed on a glass slide in a drop of strong potassium hydroxide and this wet preparation is examined immediately. The sulphur-like granule of an actinomycotic colony thus examined presents the appearance shown in Fig. 1A. A coiled group of intertwined mycelial threads terminating in clubs is the typical picture. The *Actinomyces bovis* is anaerobic and gram-positive. The *Actinomyces*-like organisms in the mouth are usually aerobic. Dr. A. T. Henrici,¹⁷ Professor of Bacteriology at the University of Minnesota, who has examined the exudate from the cases of actinomycosis observed at the University Hospital, tells me that *Actinomyces bovis* has been the organism uniformly found.

In instances in which fistulization has already occurred and drainage of exudate is slight, curettement of the sinus followed by paraffin embedding and staining with hematoxylin and eosin of a cut section will usually succeed in demonstrating the organisms when they cannot be identified in the exudate (Figs. 1B, 1C). When sinuses have long been present in actinomycosis, the organism may be difficult to find. They are most readily found in the lesion which has yet not been drained.

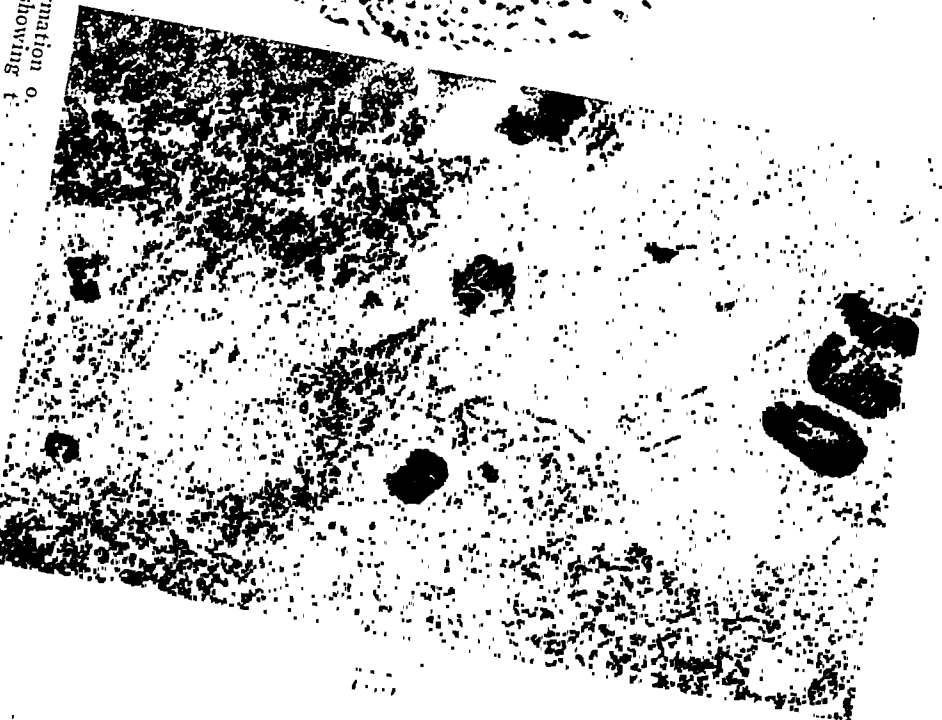
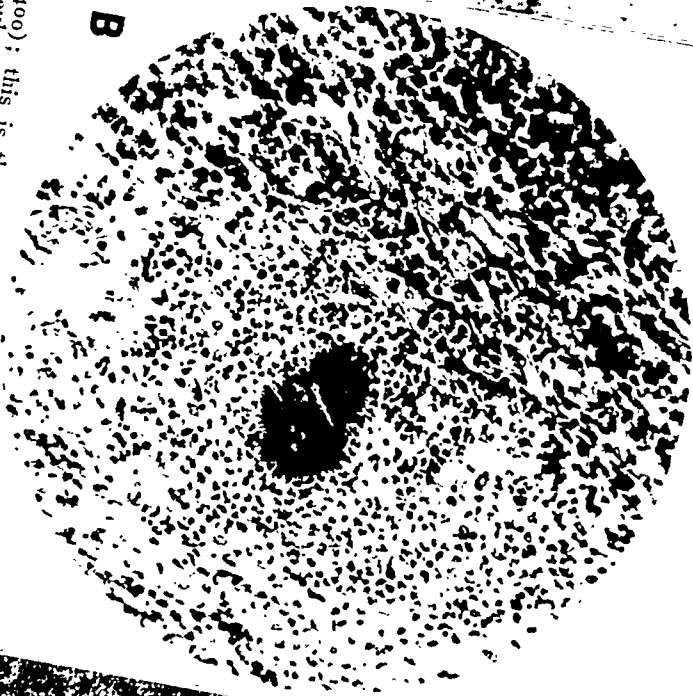
DIFFERENTIAL DIAGNOSIS: *Cervicofacial Actinomycosis*.—Very few of the cases which have come to the University Hospital for treatment have been correctly identified before admission. Persons of middle age, who have

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Fig. 1.—(A) A sulphur granule, (Gram's stain—X400); this is the typical ray fungus rosette. The conformation of *Streptothrix* (X400).



(B) A number of *Actinomyces* colonies surrounded by leukocytes. (C) A Gram's stain of a sulphur granule showing the conformation of the mycelial threads of the



the disease, are usually sent in with the diagnosis of malignancy; in younger persons the most frequent diagnosis is tuberculosis of the lymph nodes. The trismus of the muscles of the jaw and the induration of the cheek and neck with discharging sinuses frequently do suggest the picture of a late intra-oral malignancy. If the mouth can be opened adequately for examination, the absence of an ulcerating lesion should at once give increased credence to the belief that the lesion is probably actinomycosis. Malignancy, tuberculous lymph nodes, osteomyelitis of the jaw, and suppuration in a branchial cyst may mimic the appearance of this variety of actinomycosis. The finding of the organism establishes the nature of the lesion.

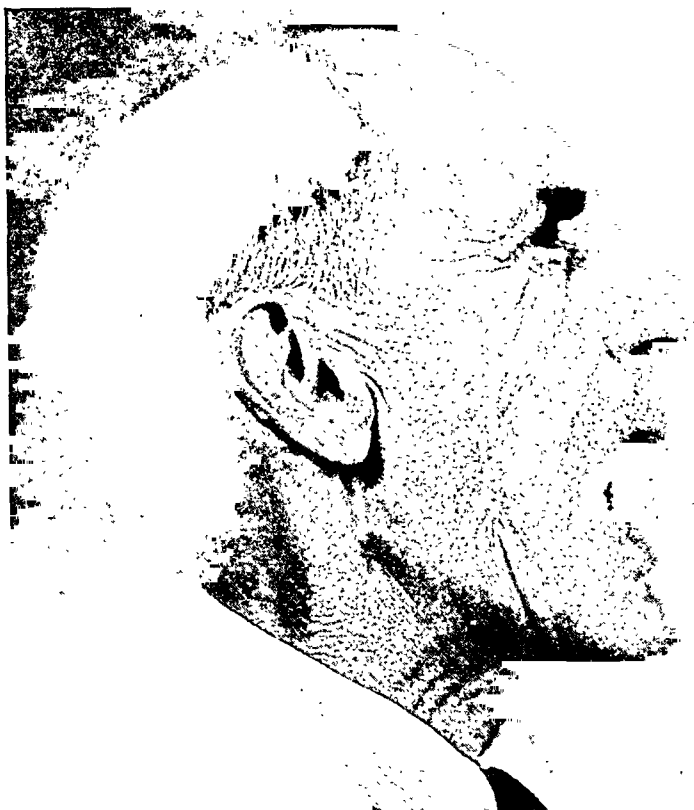


FIG. 2.—Result after complete excision of an extensive actinomycosis of the right cheek (Table I, Case 7). The trismus which patient had quickly disappeared. Cosmetic and functional result is satisfactory. Subsequent experience has shown that curetting away the dead tissue alone usually suffices to bring about the same result; it does, however, take a somewhat longer time to bring about complete healing.

Thoracic Actinomycosis.—Early recognition of the lesion is likely to be accidental. In my own experience, it is the occurrence of an empyema which is threatening to rupture through the thorax in the vicinity of the breast on the anterior chest wall which gives the first suspicion of the presence of thoracic actinomycosis. Kirklin and Hefke have indicated that the roentgenologist may occasionally diagnose the lesion when the lung, pleura, and chest wall are involved—that is, an intrapulmonary lesion which simultaneously gives rise to a periostitis should suggest actinomycosis. My experience has been that the clinician will usually suspect the presence of the lesion before

the roentgenologist will be able to suggest the possibility of its presence from roentgenograms of the chest. An instance in which, after surgical drainage of an empyema, the true nature of the lesion remained still undiscovered for a long time, has come to my attention (Table II, Case 7). The free bleeding which followed probing of the tract at once suggested the possibility of actinomycosis. Search disclosed the presence of the fungus. Pulmonary abscess, bronchiectasis with abscess or carnification of the lung, tuberculosis, malignancy of the lung or pleura, pyogenic empyema, unresolved pneumonia, syphilis of the lung, blastomycosis, and hydatid cyst may give rise to confusion.

Abdominal Actinomycosis.—Most instances of abdominal actinomycosis are operated upon for appendicitis. Exudate may be found around the appendix, the true nature of the lesion remaining wholly unsuspected. An



FIG. 3.—Actinomycosis in a child of 13 (Table I, Case 11). After two curettements complete healing resulted. Final result.

intestinal fistula may form or an abscess may appear in the incision subsequent to complete healing. The late occurrence of a subhepatic, subdiaphragmatic or perirenal abscess necessitating drainage may be the means by which the process is identified. Any sinus developing spontaneously in the abdominal wall should be looked upon with suspicion. Carcinoma, particularly in the cecum; Hodgkin's disease; appendiceal abscess, and its complications; tuberculosis of the bowel and peritoneum; so called regional ileitis with abscess formation; perinephritic abscess; and chronic granulomata are the ordinary conditions with which abdominal actinomycosis may be confused. Shiota relates that localized actinomycosis has been cured by appendectomy or intestinal resection. Cure after gastric resection, in which a surprise finding of actinomycosis was found histologically, has been reported in a few instances. Similar cures have attended drainage of a subdiaphragmatic or pelvic abscess, actinomycotic in nature, which in all likelihood had its origin

in an ileocecal lesion; like results have attended excision of an actinomycotic kidney, as well as excision of an abscess of the fallopian tubes or ovaries or a process in the uterus which was found to be actinomycotic.

Treatment.—Actinomycosis has been known as a disease entity affecting man for almost 60 years. During this time a large number of agents have been recommended and tried in combating the disease. Only three have enjoyed wide usage, *viz.*, surgery, potassium iodide, and irradiation. Among other remedies less frequently employed, the following may be enumerated: vaccine, methylene blue, copper sulphate, neoarsphenamine, and foreign protein injections.

Roentgen therapy of actinomycosis, first employed by Harsha of Chicago, did not gain many adherents until after Levy of Breslau again advised its use in 1913. Its endorsement by Heyerdahl¹⁸ of Oslo and New and Figi in this country have led to its wide employment in the treatment of this condition. That the method has virtue is adequately attested to in the numerous papers extolling the remedial properties of this therapeutic agent. The manner in which it operates is not clear. Kleesattel and Ingber²⁰ have both indicated that the roentgen ray or radium has no effect upon the organism.

The employment of potassium iodide in the treatment of human actinomycosis originated from veterinary medicine (1892). Veterinarians have since learned that potassium iodide is of no value in the treatment of *Actinomyces bovis*. In actinobacillosis, a disease of cattle and swine which mimics the pathologic aspects of true *Actinomyces bovis* closely, potassium iodide acts as a specific, terminating the disease. Actinobacillosis in man, on the contrary, has only rarely been observed. That the administration of iodide in any granulomatous infection may bring about some improvement is a matter of common knowledge. It is, however, to be acknowledged that potassium iodide is in no sense a specific in the treatment of actinomycosis, and it may also be said that it does not warrant the reliance and confidence generally accorded it. Many patients with actinomycosis are given potassium iodide until symptoms of iodism with profound listlessness and loss of appetite supervene.

An experience of many years with the employment of potassium iodide, irradiation, and surgery in the treatment of actinomycosis leads the writer to believe that surgery is the agent of greatest worth. One cannot read the papers of Heyerdahl and Engelstad^{11, 12} and escape the impression that irradiation has real merit. Experience with cases treated under my supervision and cases treated elsewhere, which have later come to my attention, have convinced me that surgery is the most direct therapeutic measure with which to attack the disease. As has been stated above, *Actinomyces bovis*, which is the organism responsible for most cases of actinomycosis observed in man, is an anaerobe. In the débris of the dead tissue which the diseased process brings about, in which the oxygen tension is zero, the organism thrives and is carried off by the macrophages into the healthy tissue in their attempt to combat the disease. Here again, new abscesses develop with death of more

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FIG. 4.—(A) Extensive actinomycosis in a child of seven (Table I, Case 13), photograph made on day of operation (9/29/34). The patient is trying his best to open his mouth. In addition to the trismus there is also slight weakness of the facial nerve. (B) Photograph taken 20 days after (A) (10/18/34). One curettment has been done in the meanwhile. The trismus has now disappeared. (C) Taken at the time of operation through which the curette was introduced. These gauze packs are changed as occasion demands (once a day to once in two or three days). The wounds healed following two curettments. (D) A recent photograph.

tissue and the establishment of new areas of low oxygen tension which constitute favorable culture media for the perpetuation of the disease. What is obviously needed is the excision of these areas of dead and dying tissue which propagate the disease. Why not employ the most direct approach known in trying to thwart the destruction of this disease? What wonder that the disease may extend itself while the indirect agents of potassium iodide and irradiation alone are being used. Yet, some roentgenologists, familiar only with the results of the agent which they employ, would relegate surgery in the treatment of actinomycosis to a place of subsidiary import or eliminate it altogether.



FIG. 5.—(A) Postero-anterior roentgenogram of a patient with thoracic actinomycosis, at time of admission, February, 1931 (Table II, Case 2). (B) Left lateral exposure. Showing mass in the left lung.

Having had the opportunity to observe the tardy and disappointing effects of a combination of potassium iodide, irradiation, and surgical restraint in the treatment of extensive cervicofacial actinomycosis, I resolved to test the efficiency of these therapeutic agents by using them separately. The results of energetic surgical treatment alone have been so gratifying that at the University Hospital we have come to rely solely on this measure of relief in the treatment of actinomycosis. At first, excision of the diseased tissue was practiced, but soon I learned that curetting away the dead tissue, leaving the wound open and providing drainage is all that is ordinarily necessary. I have been amazed to see how quickly traces of the disease will disappear and the wound heal with removal of the dead tissue. Two or three curettements alone have sufficed to successfully terminate extensive cases. In a recent instance of cervicofacial actinomycosis which had been treated else-

where by incision, large doses of potassium iodide, and skillfully administered irradiation, seven months of treatment had only led to the impression that the havoc of the disease was beyond repair (Table I, Case 14). Repeated roentgen ray treatments and continuous administration of potassium iodide had failed to stop extension of the disease. Weight loss, weakness, languor, and apathy were striking. At the first séance, the soft discolored abscess-ridden tissue of the entire left and a part of the right side of the neck were readily scraped away with the curette. The wound was packed with gauze to control hemorrhage. Two subsequent limited curettings brought about complete healing. In four months' time, less than a month of which was

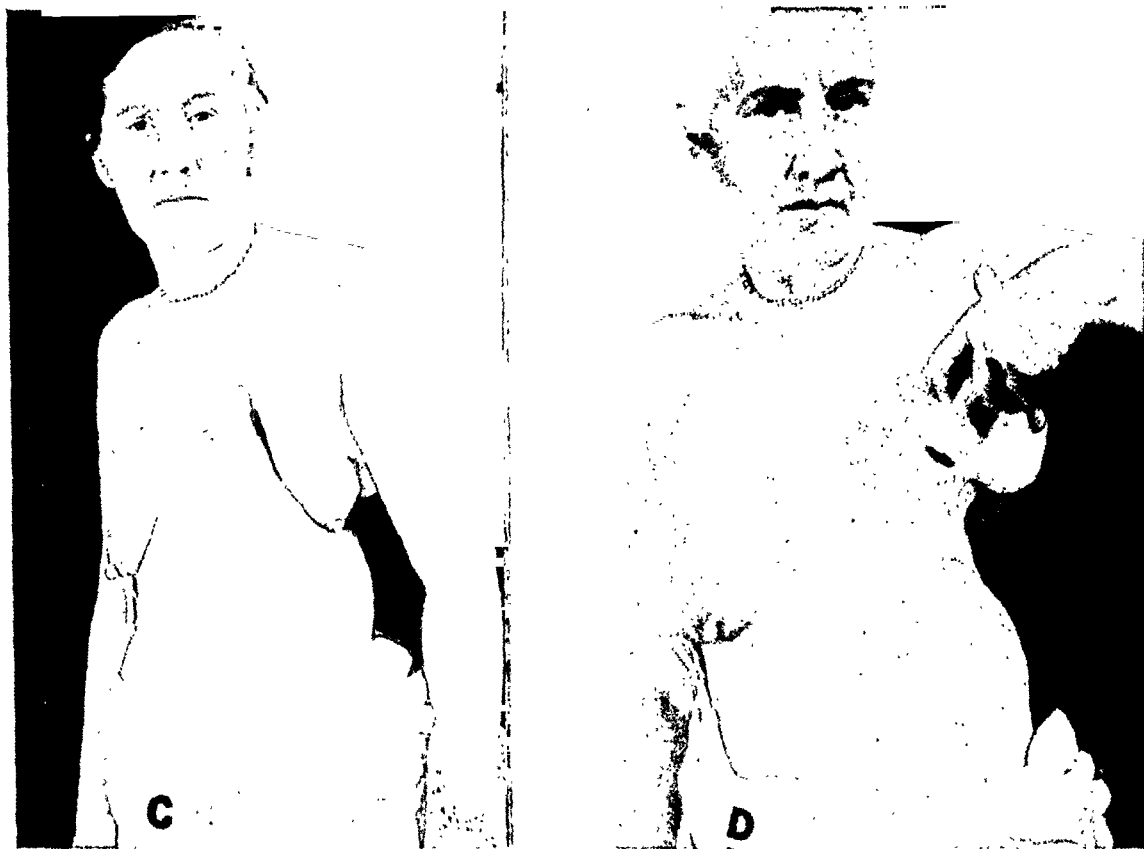


FIG. 5.—(C and D) Photographs made November 21, 1934. No evidence of actinomycosis had been found in last 18 months on three separate hospital admissions. Patient died, however, of a brain abscess March 25, 1935; whether this abscess was actinomycotic in nature is not known.

spent in the hospital, the entire raw area had granulated and become epithelialized and the wound completely healed, all without further recourse to the therapeutic agencies of potassium iodide and irradiation.

Another case was admitted in a moribund condition a few years ago to the University Hospital, as result of the ravages of a cervicofacial actinomycosis, which had been treated over an eight year period largely by potassium iodide and irradiation and an occasional incision (Table I, Case 2). A more direct approach, by energetic removal of the diseased tissue by curettement probably would have influenced the diseased process favorably.

There were two other fatal cases in the cervicofacial group of actinomycosis observed at the University Hospital. One of these (Table I, Case 1) was treated in 1925 by large doses of potassium iodide, irradiation, and roentgen therapy. The only surgery employed was the occasional opening

of an abscess by incision. It was really the disappointing experience with the remedial agents of potassium iodide and irradiation in this case which led to the employment of more aggressive surgery. Since 1930, because of the quick response obtained in energetic surgical removal of the dead tissue in actinomycosis, I have come to rely on surgery alone and have abandoned the use of potassium iodide and irradiation.

Case 3 in Table I had an extensive actinomycosis of the scalp, neck, and face of three years' duration when first seen. He was observed and treated at the University Hospital over a period of about a year and one-half. With the employment of multiple incisions and curettement, the lesions in the soft tissues cleared up fairly rapidly. A small lesion persisted near the right auditory meatus and another near the canthus of the right eye. He eventually



FIG. 6.—(A) Patient with abdominal actinomycosis (Table III, Case 4). The scar and hernia from an antecedent appendectomy for suppurative appendicitis are shown. Two curettements brought about closure of the sinuses, which however have opened up occasionally. (B) Lipiodol injection of sinus tract before curettements. No communication with the bowel is apparent.

developed signs of meningitis, from which he died. Exenteration of the contents of the orbit and opening up of the auditory canal earlier probably would have avoided this unfortunate outcome. At the time, however, it was hoped that less radical measures would suffice. Additional employment of potassium iodide and irradiation failed to do what more energetic surgical intervention probably could have accomplished.

My own experience with the treatment of thoracic and abdominal actinomycosis affords no occasion for optimism. Yet, if the disease can be diagnosed early and prompt evacuation of the dead tissue effected, the means of extending the disease is done away with. I believe that at least some of these cases are amenable to treatment. The literature is most pessimistic over the outlook in thoracic actinomycosis, and the prognosis in the abdominal variety does not appear much brighter. Yet, cures in thoracic as well as

abdominal localization of the disease are well known. A patient with thoracic actinomycosis, which I reported in 1932, has since died of what her physician interpreted to be a brain abscess (Table II, Case 3). Since she first came to the hospital in 1931, she returned at six month intervals for observation. During the last 18 months of life, no evidence of residual actinomycosis could be detected. Unfortunately, postmortem examination was not obtained, and whether the abscess was actinomycotic will never be known. A surgical procedure in 1932 on the lung, moreover, was followed by the signs of an intracranial abscess in the left motor (hand) area which cleared up completely; the propagation of an actinomycotic thrombus to the brain is well known. However, shortly before her fatal illness, her physician informed me, she had a very severe pansinusitis.

At present I have two patients under treatment for thoracic actinomycosis. One of these undoubtedly began as an abdominal actinomycosis; subphrenic infection with penetration of the diaphragm, the establishment of an empyema and perforation of the chest wall occurred (Table II, Case 7). There is no divining-rod which will tell whether all the foci have been uncovered; and the tendency for the disease to burrow in every direction is well known. The problem with these cases is early recognition of the presence of actinomycosis, evacuation of the exudate and dead tissue—including all the pockets. In those instances in which the diseased process remains well localized, and particularly if dissection towards the surface occurs, prompt and adequate treatment is likely to bring about a cure.

Another patient (Table II, Case 5) with extensive actinomycosis of the thorax is also still under treatment. This process involved the left lung and the greater portion of the left pleural cavity, as well as a considerable portion of the left chest wall. An actinomycotic abscess of the left axilla, another in the groin, and one over the left half of the sacrum have also been evacuated. The greater portion of the entire left chest is bare and the scapula as well as breast is separated from the chest wall. Despite the unusual extent of the lesion and its obviously discouraging features, I have not wholly despaired of being able to do something for this young girl.* Potassium iodide and irradiation, which leave in their wake anorexia and frequent vomiting, I have not looked upon as promising enough to warrant a trial. The contents of abscesses are curetted away as they appear; the wounds being extensive, the changing of dressings is a painful procedure. Every third day, under brief intravenous evipal anesthesia, the wounds are carefully reexamined and dressed. Dakin's solution, dichloramine T, and zinc peroxide have proved most efficacious in keeping these wounds clean.

IMPORTANT PROBLEMS RELATING TO ACTINOMYCOSIS.—The most significant issue demanding solution concerning actinomycosis is its etiology. As was previously mentioned, the general opinion is that actinomycosis is an

* Since this was written both these patients have died. Case 5, Table II had a small residual process in the left lung. No evidence of actinomycosis was found in the other previous areas of involvement. Case 7, Table II also had a residual process in the lung, and, in addition, a small hepatic abscess (1×2 cm.) just beneath the surface of the dome of the liver.

RESULTS OF TREATMENT OF ACTINOMYCOSIS*
TABLE I. CERVICOFACIAL CASES

Patient, Hospital Number, Sex, Age, Admission Date	Extent of Lesion	Treatment	Result	Remarks
Fatal cases:				
(1) A. S.—33878 Male—43 yrs. 11/16/25	Right side face and neck; left side face and neck	Roentgen ray, radium, KI, in- cisions	Died 7/19/26	Energetic sugrical intervention (curet- ting) probably would have cured.
(2) M. F.—621288 Female—31 yrs. 10/11/33	Orbit and scalp	No treatment here, elsewhere over an eight year period	Died 10/15/33	Undoubtedly there was too much re- liance upon irradiation and po- tassium iodide.
(3) J. G.—622467 Male—65 yrs. 10/20/33	Entire right side face, neck and scalp, three years' duration	Roentgen ray, ra- dium, and an occasional incision	Died 7/7/35	Died of an actinomycotic meningitis; a far advanced case when first seen. Exenteration of contents of right orbit may have obviated fatal men- ingitis. All facial actinomycosis ex- cept that of orbit under control at time of death. There was also found involvement of right middle ear at postmortem examination.
Recovered cases:				
(4) A. D.—38703 Male—65 yrs. 1/30/27	Right side of face and neck	Multiple incisions, drainage. KI and roentgen ray	Well	
(5) L. C.—42646 Male—34 years. 1/6/28	Right side of face and neck	Incisions, KI, and roentgen ray	Well	
(6) M. B.—567683 Male—43 yrs. 6/25/30	Tongue	Incisions, drainage, KI, and roentgen ray	Well	
(7) A. G.—55891 (Fig. 2) Male—40 yrs. 10/6/30	Large lesion in right cheek, unable to open mouth	One surgical excision	Well	Temporary parotid fistula, healed with small residual scar; function good.
(8) G. M.—62058 Male—46 yrs. 1/5/32	Right side of face, ear, and neck, three years' duration	One curettement; two excisions	Well	
(9) A. S.—60976 Female—29 yrs. 1/5/32	Large mass of recent origin beneath left jaw	Two excisions	Well	
(10) C. K.—611438 Male—39 yrs. 11/14/32	Tongue, of short duration	One incision and packing of tongue	Well	
(11) I. O.—608171 (Fig. 3) Female—13 yrs. 7/30/32	Entire right side of face, three months' duration	Two curettements, subsequent ex- cision of scar	Well	
(12) M. W.—631475 Female—35 yrs. 9/27/34	Right side of face and neck	One excision, wound left open to heal by granulation	Well	
(13) A. B.—631495 (Fig. 4) Male—7 yrs. 9/28/34	Right cheek, right side neck; behind right ear	Two curettements	Well	
(14) L. H.—642452 Male—52 yrs. 9/29/35	Left cheek, left side neck from sternum to ear with recent	Two excisions of tissue including greater portion of	Well	Seven months' treatment elsewhere with intensive irradiation and KI and opening of abscesses. Family had

been told that prognosis was very poor. Under treatment the patient had only become more apathetic. Weight loss 50 pounds. Four months after first evacuation of actinomycotic dead tissue here, wound was healed and patient had regained weight and vigor.

* In all but the doubtful cases (Table IV), *Actinomyces* were demonstrated morphologically and culturally (*Actinomyces bovis*). The writer here wishes to acknowledge the help which the keen interest of Dr. A. T. Henrici, Professor of Bacteriology, and his associates have afforded in the identification of these cases.

TABLE II. THORACIC CASES

	Left lung and chest wall	KI and roentgen rays	Died after leaving hospital	
(1) E. A.—49008 Male—21 yrs. 2/29/29				
(2) A. P.—55740 Male—13 yrs. 9/25/30	Suppurative pneumonic pericarditis and mediastinitis with compression of the esophagus	Bed rest	Died 1/19/31	Actinomycotic nature of lesion not apparent until autopsy.
(3) E. B.—615300 (57754) Female—29 yrs. 2/14/31 (Fig. 5)	Left lung, chest wall and breast	Numerous rib resections and subsequent curettements	No evidence of residual actinomycosis during last 18 months of observation. Died of brain abscess	Brain abscess may have been actinomycotic; no autopsy. Patient did have serious pansinusitis before symptoms of cerebral abscess developed. (Case reported in detail elsewhere.)
(4) J. S.—612412 Male—15 yrs. 12/10/32	Left chest wall with supradiaphragmatic collection in both chests and involvement of spleen and liver	Bed rest, incision of abscesses over left chest wall and excision of one rib	Died 2/4/33	Presented as a case of actinomycosis of left thorax, but probably began as abdominal actinomycosis. Abscesses of liver were prominent at autopsy.
(5) L. W.—640072* Female—15 yrs. 7/2/35	Left lung, pleura, and chest wall, including left breasts, left axilla. Actinomycotic abscesses of left groin and left buttock	Incision, rib resections, curettements, packing and transfusions	Still under treatment	
(6) J. N.—646103 Male—57 yrs. 2/18/36	Right lung, suppurative pericarditis, and actinomycotic abscess of right kidney	Bed rest	Died 2/28/36	Presented as thoracic actinomycosis, probably an antecedent abdominal lesion
(7) J. L.—646743* Male—45 yrs. 3/10/36	Right lung, pleura, chest wall, and subdiaphragmatic collection	Excisions, curettements, packings, transfusions	Still under treatment	Antecedent appendectomy about seven months before, followed by empyema which was drained elsewhere. Free bleeding of sinus tract suggested diagnosis.

* See footnote on page 763.

TABLE III. ABDOMINAL CASES

Patient, Hospital Number, Sex, Age, Admission Date	Extent of Lesion	Treatment	Result	Remarks
(1) J. T.—12506 Male—37 yrs. 10/23/17	Fecal fistula of abdominal wall, abscess and retroperitoneal collection	Cautery, drainage, packing	Died 6/14/18	Antecedent appendectomy.
(2) H. N.—50181 Male—27 yrs. 10/4/29	Abdominal wall with peritonitis of pubis and induration of right thigh and buttock	Incisions, KI, and roentgen ray	Died	Operated upon for appendicitis one year before.
(3) A. M.—56820 Female—51 yrs. 12/7/30	Sinuses in abdominal wall with large retroperitoneal mass	Incisions, KI, and roentgen ray	Died	Appendectomy for acute suppurative appendicitis two and one-half years previously. At time of drainage here, peritoneal cavity was opened and drained, and fistula developed. Antecedent operations with drainage for acute suppurative appendicitis, followed by large incisional hernia (Fig. 6A).
(4) W. J.—613527 (Fig. 6) Male—59 yrs. 1/6/33	Right lower abdominal wall and retroperitoneal region extending from pelvis to diaphragm, including liver	Two curettements and packing	Still under treatment. Sinus still open; general condition satisfactory	
(5) L. B.—640854 Male—28 yrs. 7/30/35	Abdominal wall and retroperitoneal region extending from pelvis to diaphragm, including liver	Excision of visible and accessory lesions, transfusion	Died 1/9/36	Six months prior to first admission, patient had appendectomy for suppurative appendicitis with abscess; developed fecal fistula.

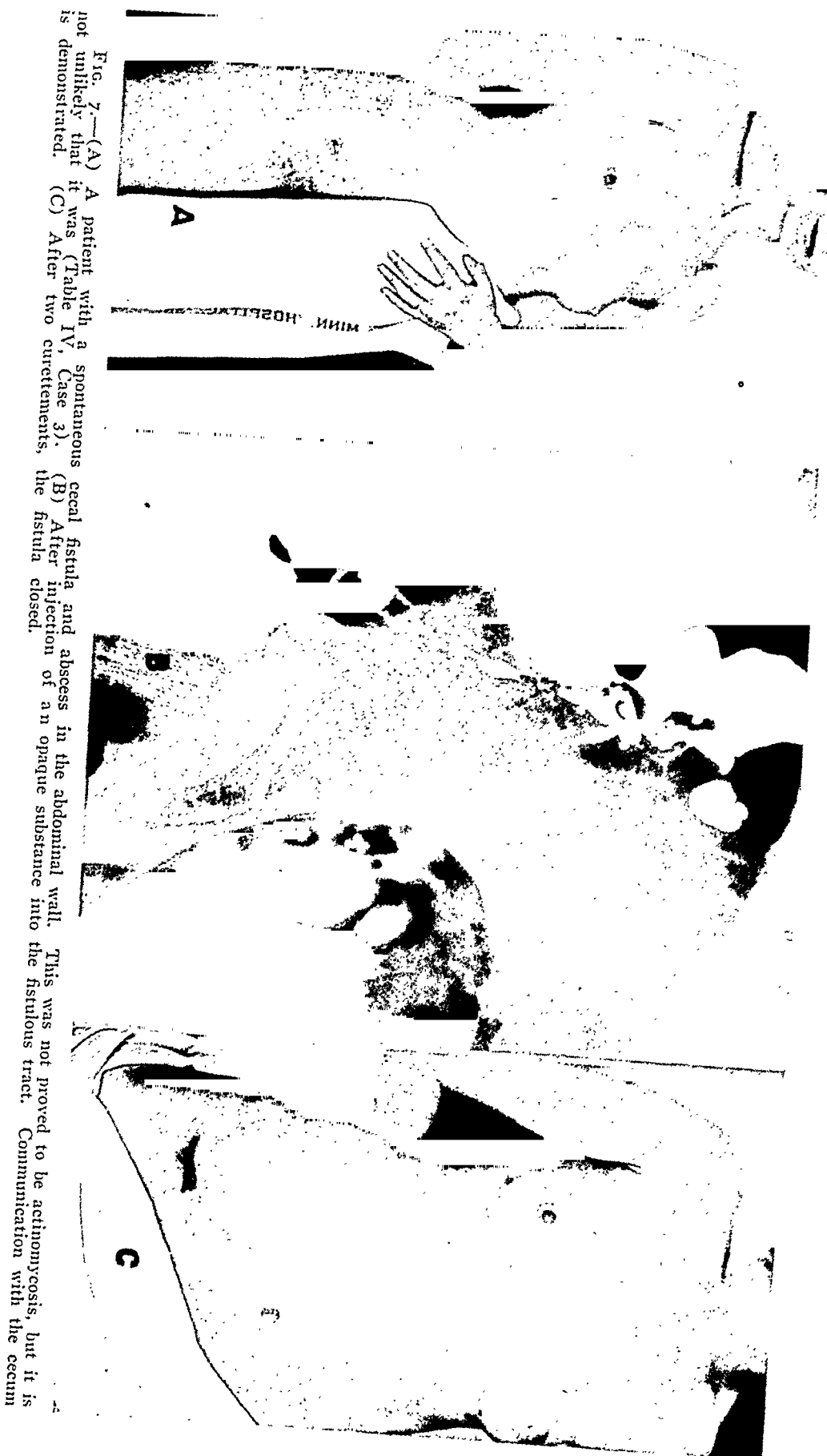
(See also Thoracic Cases: Case 4, J. S.; Case 6, J. N.; and Case 7, J. L.)

TABLE IV. DOUBTFUL CASES*

	Tongue	Incised by supra-hyoid approach, with excision of abscess and tract in tongue	Well	
(1) E. C.—64853 Male—16 yrs. 7/19/32	Tongue	Intra-oral incision into tongue and packing	Cured (Died two years after hospitalization in gasoline explosion)	Painful swelling with pain over two and one-half years with previous operation. Chronic abscess of doubtful origin. <i>Actinomyces</i> not found.
(2) J. N.—611778 Male—46 yrs. 11/25/32	Tongue	Curettement	Well	Clinical diagnosis, actinomycosis. Sulphur granules present. No <i>Actinomyces</i> demonstrated. Final diagnosis, therefore, abscess of tongue, probably pyogenic in nature. No <i>Actinomyces</i> found. Histologic diagnosis, chronic inflammation. Fistula developed spontaneously with subsequent abscess in abdominal wall. No antecedent intraperitoneal operations.
(3) M. L.—613359 Female—28 yrs. 2/6/33	Fecal fistula with dissection tract going down into pelvis	Curettement	Well	Mycelia with peripheral clubs demonstrated which were identical with <i>Actinomyces</i> . On culture, only <i>Staphylococci</i> grew.
(4) M. L.—645356 (Fig. 7) Male—20 yrs. 1/20/36	Osteomyelitis of the right scapula with sinuses near spine and tip of scapula	Curettement	Well	

* Clinically, actinomycosis appeared to be the most likely diagnosis. These cases were classified as doubtful when morphologic and cultural studies failed to show the presence of *Actinomyces*.

ACTINOMYCOSIS



exogenous infection. There are those who hold, however, that it is endogenous in origin, from organisms within the mouth. Naeslund^{26, 27} would compose these conflicting opinions by findings of his own which suggest that actinomycosis may be caused by the organisms which inhabit the mouth as well as by the *Actinomyces bovis*. The former, he says, gives rise to much less serious infections. This is essentially a bacteriologic problem and one which I do not feel competent to discuss. Its solution is vital for the formulation of intelligent efforts directed at preventing the disease. When it is definitely known how the disease reaches man and gets its start, an important step will have been taken in the direction of prophylaxis of the disease.

Next in importance is early recognition of the presence of actinomycosis—particularly visceral manifestations of the disease. Almost invariably an extensive suppurative process is present in the thoracic and abdominal forms before the disease is identified. Efforts have been made to detect the presence of actinomycosis by cutaneous reactions similar in character to the Mantoux test for tuberculosis, but there is no evidence that such tests at present are worth while. When suppuration has already occurred, employment of the well known bacteriologic and pathologic criteria of examination should insure recognition of the diseased process. Early recognition and early evacuation of the dead tissue will prevent dissection and obviate the collection of exudate in pockets remote from one another. It is this occurrence which accounts for the poor prognosis in the visceral forms of the disease. By the time the nature of the suppurative process is properly identified, widespread dissection has occurred. And unlike a pyogenic abscess, tenderness is frequently absent following initial drainage. A residual pocket, even though in the proximity of the drainage tract, may not be uncovered until it later ruptures into the sinus of the drainage tract. Unfortunately, in the meanwhile, it is also extending itself in other directions. It is highly important, therefore, that actinomycotic wounds be frequently and meticulously examined. When a pocket has been well curetted, persistent drainage usually means an adjacent focus.

The manner in which the wound is treated is probably of far less importance than early drainage of all the pockets. Inasmuch as the organism is an anaerobe, zinc peroxide, as advised by Meleney²⁵ for anaerobic infections, should be useful. In the main, however, the consideration of most consequence is whether all the actinomycotic débris has been curetted away.

SUMMARY AND CONCLUSIONS

The cases of actinomycosis which have been seen at the University Hospital are reviewed. Examination of the data pertaining to them indicates that the prognosis of cervicofacial actinomycosis is good unless too much reliance is placed on the therapeutic response to the administration of potassium iodide and the employment of irradiation. The prognosis in thoracic and abdominal actinomycosis is poor. With earlier recognition and adequate

evacuation of dead tissue in visceral forms of the disease, the outlook will probably improve.

The most direct agency in the treatment of actinomycosis is surgery. The rationale of surgical treatment lies in the fact that the infection is essentially an anaerobic one. Removal of the dead tissue, which is poorly oxygenated and in consequence an excellent culture medium, will usually terminate the disease. Many instances of cervicofacial actinomycosis respond favorably to curettement alone. In extensive cases, energetic surgical excision of devitalized tissue is indicated.

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THE SURGICAL TREATMENT OF ESSENTIAL HYPERTENSION

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IT is obviously impossible to present, in any comprehensive way, a discussion of the problems of essential hypertension and of its surgical treatment in such an abridged article as this. A fairly complete report of the work which Dr. Irving Page and I have done thus far has been prepared and will appear shortly, to which reference may be made by those who are interested. I wish to report, however, briefly the considerations which led to the adoption of certain surgical procedures, the selection of patients for operation, the methods of control used in studying patients before and after operation, and the results of operation which thus far have been obtained.

The time at which Doctor Page and I became associated in this work, early in 1934, was a period of great activity in the surgical treatment of hypertension; and a survey of the literature showed that American, French, German and Italian authors had published a variety of surgical and other procedures for its cure or amelioration. The therapeutic procedures described consisted in the reduction of the activity of the basophilic cells of the hypophysis by radiation, in denervation of the adrenal glands, in subtotal adrenalectomy, in splanchnicotomy and in anterior nerve root section. While the causation of essential hypertension was, and is not, known, the theories upon which these therapeutic procedures were based were chiefly three: that hypophyseal basophilism played an important rôle in the genesis of the disease; that overactivity of the adrenal glands resulting in a hyperadrenalemia was an essential factor; and that chronic spasm of the arterioles in the splanchnic area was an important cause of the elevated blood pressure. Evidence of whatever nature in support of these theories was sought and subjected to critical analysis; and as a result Page and I concluded that a surgical procedure which had as its purpose the relaxation of the presumably spastic arterioles of the splanchnic area and the denervation of the adrenal glands offered greater possibilities than others which had been suggested and tried. The choice of procedures, then, lay between splanchnicotomy and anterior nerve root section and we decided to make as accurate a study as possible of the results of both procedures. That we selected anterior nerve root section for our first study was the result of a survey of available anatomic and physiologic data. Even granting the possibilities of anatomic abnormalities and "overlap" in the distribution of the sympathetic nerves, it seemed to us that section of the sympathetic fibers at their point of emergence from the cord by division of the sixth dorsal to the second lumbar motor spinal nerves was a more certain method of inhibiting the sympathetic innervation of the

abdominal blood vessels and adrenal glands than section or resection of major and minor splanchnic nerves combined with lower dorsal ganglionectomy. The procedure was therefore attempted or carried out in 21 cases. At the time of the first operation, May 11, 1934, the only case of which we knew who had been treated by this method had just been reported. This was the case of Adson and Brown, and while the results were far from ideal, it was thought that the fault lay in the selection of the case and that the operation should be tried in cases in which the vascular tree was still flexible. It was realized that the operation was the most difficult, the most time consuming and the most dangerous of the procedures which had been suggested. That our fears of the possibilities of harm to patients in this operation have been to some extent realized, I shall indicate later.

In the selection of patients for operation, it seemed probable that those in whom an elevated blood pressure was the only objective manifestation of disease on physical examination, might be expected to respond most favorably to surgical treatment. Nevertheless, it was thought desirable to attempt the procedure in groups of cases, the groups representing stages in the severity of the disease; for aside from determining its value it seemed important to determine, if possible, its limitations. In determining groups of this sort, various criteria were used. The flexibility of the vascular tree was determined by the fall in blood pressure when the patient was put to bed; by the fall in blood pressure after the intramuscular injection of colloidal sulphur or acetyl- β -methylcholine (mecholine); after administration of sodium thiocyanate by mouth and after the inhalation of amyl nitrate; and by the daily fluctuations in the level of the blood pressure as determined by a long period of observation. Evidences of cardiac damage, of extensive changes in the ocular fundus and of renal damage with renal insufficiency were criteria which, in addition to vascular flexibility, were used to indicate the stage of the disease or its degree of advancement in the patients who were studied and subjected to operation. Such patients represented examples of the disease which varied from the benign essential hypertension of short duration to the highly malignant hypertension.

The prolonged observation and scientific study of patients before and after operation seemed most essential in determining the value of our therapeutic procedures. A study of all case reports in the literature showed the extraordinary difficulties in evaluating the results of different surgical operations, and largely because of the paucity of reported observations before and after operation. The great variability in the manifestations of essential hypertension makes it necessary that repeated observations, comprehensive in their scope, be made by one familiar with the disease in order to determine accurately the effects of any given procedure. What value there is in our work largely lies, I think, in the accuracy and completeness of the observations made before and after operation. The patients subjected to this study were first hospitalized in the Hospital of the Rockefeller Institute for at least 30 days, and frequently for a longer period, for a preliminary or preoperative

period of study. The flexibility of the vascular tree was estimated by the tests above indicated. The blood pressure was taken daily at a fixed time (9:30 A.M.) with the patient in bed, its fluctuations established and a mean or average blood pressure determined. Changes in the eyegrounds noted were constriction of the arterioles, arteriosclerosis, exudates, hemorrhages and papilledema. Changes in the heart were determined by physical examination, measurements of roentgenograms, and electrocardiographic studies. The basal metabolic rate was regularly determined. Renal efficiency was measured by urea clearance and the ability of the kidneys to concentrate urine. The specific gravity of the urine was determined in a 12 hour specimen voided at the end of 24 hours without fluids; in case proteins were present in sufficient amounts to contribute to the specific gravity, a correction was made for it. The number of formed elements in the urine was determined by the technic of Addis. The urine protein was measured by the method of Shevky and Stafford as modified by MacKay. The plasma proteins were ascertained by the method of Howe; hemoglobin was measured by the method of Van Slyke and Neill. The general study of the patient included observations upon the subjective manifestations of the disease, upon psychic abnormalities and upon evidences of stability of the nervous system. After convalescence from operation, the patients were again transferred to the Hospital of the Rockefeller Institute and all the above observations and examinations repeated. In the follow up, the patients have periodically been hospitalized for a week or ten days and again studied. It would appear that the results we have to report are as accurate as can be determined in the human subject with known methods of examination. An example of the data record incorporating these observations is shown in Chart 1.

The operation of anterior nerve root section consists in the bilateral division of the anterior roots of the sixth dorsal to the second lumbar spinal nerves. The positive identification of the spinous process of the first lumbar vertebra and its relation to the overlying skin has been helpful in determining the lower limit of the incision. The identification of the last digitation of the dentate ligament after the dura has been opened has aided in determining the roots to be divided; for it is attached to the dura between the twelfth dorsal and the first lumbar nerves. In our early experience the entire operation was performed at one sitting. The disadvantages of this were found to be chiefly two: its duration and its consequent hardship upon both patient and surgeon; but more important the fall in blood pressure as the result of the laminectomy, so that the essential part of the operation—the division of the anterior nerve roots—sometimes could not completely be carried out. In our later experience the operation has been divided into two stages, the first terminating with the completion of the laminectomy and the complete exposure of the dura; the second consisting in the opening of the dura and the division of the anterior nerve roots. An interval of several days to a week is allowed to elapse between these stages, during which the blood pressure will have returned to its preoperative level. In the division of the

nerve roots every precaution has been used to avoid injury to the cord and every effort has been made to preserve the small nutrient blood vessels entering the cord along the nerve roots. A sketch of the essential part of the operation is shown in Figure 1.

The operation of splanchnic nerve resection has been performed according to the technic of Max Peet. It is a supra-diaphragmatic approach through a vertical incision with the subperiosteal resection of the mesial portion of the eleventh rib. The pleura is stripped from the bodies of the vertebrae, the major splanchnic nerve is identified and a section 7 to 8 cm. long is removed. The tenth, eleventh and twelfth dorsal ganglia with the minor splanchnic nerve are then removed. The operation has been performed bilaterally and has been done either at one or at two sittings, separated by a week's interval. The subdiaphragmatic approach suggested and used by Craig and the more recent subdiaphragmatic approach with resection of the splanchnic nerves, two upper lumbar ganglia and portions of the adrenal glands, as described by Adson, have not yet been employed by us.

In the reports of results of various surgical procedures, observers have commented upon both subjective and objective improvement. By subjective improvement is meant the amelioration or disappearance of such symptoms as headache, vertigo and palpitation of the heart; by objective improvement, the actual lowering of blood pressure, disappearance of papilledema, and so forth. Experience shows that improvement in subjective symptoms may take place without marked lowering of the blood pressure; it shows also that improvement in subjective symptoms practically always occurs in conjunction *with* a fall in the blood pressure. In an appraisal of the value of surgical procedures in the treatment of hypertension, it would seem obvious that procedures which cause a per-



FIG. 1.—The operation of anterior nerve root section. The dura mater is held apart with a series of silk sutures. The clamps grasp the digitations of the dentate ligament, traction upon which rotates the cord, and bring the anterior spinal roots into view. An anterior nerve root is shown divided between ligatures of fine silk. A blunt hook is shown lifting up a root preparatory to ligation and section.

manent or long continued reduction in the level of the blood pressure are the procedures of choice.

Results of Anterior Nerve Root Section.—Up to April 1, 1936, anterior nerve root section had been attempted in 18 cases. The results are summarized in Table I. Certain comments upon these cases may be added by way of elaboration of the data shown.

In three cases the operation was not carried beyond the first stage. One patient (No. 17 in Table I) recovered promptly from the operation but thus far has refused to submit to the second stage. It will be observed that his

TABLE I

Summary of Clinical Data of 18 Patients on whom Root Section was Performed.

No.	Age	Duration of Hypertension	Retinal Changes	Urea Clearance	Av. Blood Pressure before Operation	Number of Pairs of Roots cut	Av. Blood Pressure after Operation	Subjective Improvement
	yrs.			Percent of normal	mm. Hg.		mm. Hg.	
1	25	18 mos.	0	104	190/122	9	150/94	Very marked
2	24	+ 2 yrs.	+	80	206/148	5	162/98	Very marked
3	17	18 mos.	+	106	180/122	5	140/90	Very marked
4	32	8 yrs.	0	101	210/130	5	154/104	Marked
5	35	3 yrs.	+	88	190/122	6	176/114	Marked
6	25	3 yrs.	+	91	184/116	9	156/106	Marked
7	40	2 yrs.	++	72	230/142	4	210/122	Marked
8	25	2 yrs.	++	74	210/130	6	162/110	Marked
9	24	7 mos.	+++	92	190/120	5	162/110	Marked
10	26	+ 3 mos.	+++	30	190/124	5	190/138	No symptoms before op.
11	33	10 yrs.	0	90	258/140	6	182/116	Moderate
12	46	15 yrs.	+++	68	270/160	5	230/142	Marked
13	37	2 yrs.	+++	55	270/170	6	210/140	Moderate
14	44	3 yrs.	+++	88	200/152	6	158/106	Marked
15	26	1 yr.	+++	18	200/110	7	Patient died shortly after dura was closed.	
16	21	2 yrs.	0	119	200/152	0	140/100	No symptoms before op.
17	37	7 yrs.	+	42	250/140	0	232/140	Questionable
18	39	6 yrs.	+++	86	270/148	0	Patient died from Streptococcus Meningitis	

* The elapsed time since operation in the first 14 cases varies between 1 and 2 years.

blood pressure remains at the preoperative level. Clinically he represented an advanced stage of the disease. One patient (No. 18) developed symptoms of meningeal irritation following the first stage and died from a Streptococcus meningitis. The dura had been opened only in the sense that a hypodermic needle had penetrated it for the purpose of withdrawing some cerebrospinal fluid. The meningitis probably was the result of a gross error in technic. One patient (No. 16), during his recovery from general anesthesia after the first stage, is said by two observers to have moved his legs; but when observed the morning following operation there was clear evidence of a transverse lesion of the cord at the level of the upper end of the incision. Believing that extradural hemorrhage causing compression of the cord might be the cause of his condition, the wound was reopened and a considerable clot was evacuated. There was no hemorrhage beneath the dura, as demonstrated by its color and by the aspiration of clear cerebro-

spinal fluid. Hoping that the extradural clot was sufficient to explain the symptoms of cord compression, the wound was again closed without opening the dura. For a period of eight days we awaited some evidence of returning function; then reopened the wound, removed the laminae of two dorsal vertebrae above the upper limit of our previous exposure and opened the dura throughout the entire length of the operative defect in the spine. There was not the slightest hemorrhage beneath the dura and the most careful examination of the spinal cord failed to reveal any trauma of the external surface of the cord or evidence of hemorrhage or other lesions within the cord. Since this operation (three months) there has been a slow return of function; but that there will be a restoration to normal function seems at present very doubtful. It is to be noted that as the result of a cord lesion at the level of the sixth dorsal, a fall in blood pressure has occurred and persisted as in cases in which the anterior nerve roots have been divided.

In 15 cases the operation of anterior nerve root section was completed in one or two stages. One patient died at the termination of an operation performed in one stage; and for want of a better explanation the death is ascribed to surgical shock. The autopsy showed generalized arteriosclerosis, arteriolar nephrosclerosis, detachment of the retinae with retinal hemorrhage, partial atelectasis of the lungs, persistent thymus and cholelithiasis. The case was one of our early ones, and was the most advanced case of malignant hypertension in the series; it is doubtful, in retrospect, whether the operation should have been undertaken.

Of the 14 patients who survived the completed operation, three are improved, but the duration of time is not sufficient to warrant comment on the results; 14 have been observed for from one to two years since operation. Of these 14, five have roughly been grouped on the basis of duration of the disease, retinal changes, evidences of arteriosclerosis and of renal damage, as mild or moderately severe examples of essential hypertension; while nine have been classified as examples of advanced and severe hypertension or as malignant hypertension.

In Table I the first five cases represent the mild and moderately severe examples of the disease, the sixth to the fourteenth cases, inclusive, represent the advanced and severe examples of the disease. Subjective improvement has been very marked in three, marked in eight, and moderate in two of the cases. Improvement in subjective symptoms has, therefore, occurred in 100 per cent. Objective improvement—the lowering of the blood pressure during the period of observation, the improvement in the condition of the eye-grounds, and so forth—has varied appreciably, and in order to form a just estimate of the results, it is necessary to analyze each case separately. Perhaps a general idea of the results may be obtained from the appended summary.

SUMMARY.—In four out of the five cases of mild or moderately severe hypertension, the systolic pressure before operation varied between 180 and 220 and averaged 196.5; the diastolic pressure before operation varied be-

tween 122 and 148 and averaged 130.5. The permanent (during period of observation) fall in systolic pressure after operation varied between 40 and 56 Mm. and averages 45 Mm. The permanent fall in diastolic pressure after operation varied between 26 and 50 Mm. and averages 34 Mm. The lowering of the blood pressure represents 22.6 per cent of the preoperative systolic level and 25.5 per cent of the preoperative diastolic level. The patients represent a group which, having had a blood pressure before operation of 196/130, have had since operation a blood pressure of 150/95; a blood pressure which approaches, but is not, normal.

In one of the cases of mild or moderately severe hypertension, the blood pressure before operation was 190/122 and since operation has been 176/114. There has been, therefore, a fall of only 14 Mm. in the systolic pressure and 8 Mm. in the diastolic pressure. The result in this case is far less satisfactory than in the other four.

In four of the nine cases of advanced, severe hypertension, the systolic pressure before operation varied between 200 and 270 and averaged 235; the diastolic pressure before operation varied between 130 and 170 and averaged 143. The permanent fall in systolic pressure after operation varied between 42 and 76 and averaged 56.5 Mm.; the permanent fall in diastolic pressure after operation varied between 20 and 30 and averaged 25 Mm. This lowering of blood pressure represents 23.8 per cent of the preoperative systolic level and 17.5 per cent of the preoperative diastolic level. The patients represent a group which, having had before operation a blood pressure of 235/145, have had since operation a blood pressure of 178/118, a pressure considerably above normal. It will be noted that the percentage fall in the systolic pressure in this group is equal to that in the mild and moderately severe group, but that the percentage fall in diastolic pressure is less than that in the previous group. Although the operation achieved the same percentage fall in systolic pressure as in the preceding more favorable group, the fact that the blood pressure before operation was considerably more elevated leaves this group with a greater degree of hypertension. (One of these patients has since died of apoplexy. That the reduction in blood pressure prolonged his life cannot of course be stated; that the operation hastened his end we do not think likely.)

In four of the nine cases of advanced, severe hypertension, the systolic pressure before operation varied between 184 and 270 and averaged 218; the diastolic pressure before operation varied between 116 and 160 and averaged 134.5. The permanent fall in systolic pressure after operation varied between 20 and 40 and averages 29 Mm.; the permanent fall in diastolic pressure after operation varied between 10 and 20 and averages 14.5 Mm. This lowering of blood pressure represents 13.3 per cent of the preoperative systolic level and 10.5 per cent of the preoperative diastolic level. The patients represent a group which, having had before operation a blood pressure of 218/135, have had since operation a blood pressure of 189/120, a pressure again considerably above normal. It is to be noted in

this group that the percentage fall in systolic and diastolic pressures following operation is very much less than in the preceding two groups of cases. (Of these cases one has since died of apoplexy.)

In one of the nine cases of advanced, severe hypertension, the systolic pressure before operation was 190 and the diastolic pressure 124. Following operation the systolic pressure has continued to be 190 but the diastolic has increased to 138. The operation in this case has had no effect upon the blood pressure. (The patient has since died of uremia.)

It will be noted that in all cases except one, anterior nerve root section has been followed by a fall in blood pressure which has persisted for from one to two years. In mild and moderately severe hypertension, four out of five cases, or 80 per cent, have shown a satisfactory reduction in blood pressure. In severe and malignant hypertension, four out of nine cases, or approximately 45 per cent, have shown a fairly satisfactory reduction in blood pressure; while one out of nine, or ten per cent, has failed to show any reduction in blood pressure. The attempt to determine the reasons for fairly good results in 80 per cent of the mild and moderately severe cases and 45 per cent of the severe, advanced cases does not at present lead to any definite conclusions. Our experience thus far shows that neither in the mild nor severe cases can anterior root section be expected to cause a permanent reduction of more than 25 per cent of the preëxisting systolic and diastolic pressures. Perhaps in part because of this, we have found that patients whose disease is benign without advanced morbid vascular changes and young patients exhibiting signs of the hypertensive diencephalic syndrome are fairly certain to be greatly benefited by operation; patients with benign hypertension of long standing with marked arterial thickening form a more uncertain group from the viewpoint of results; while patients with malignant hypertension form a very uncertain group in whom the outcome cannot at present accurately be predicted.

Aside from the results with respect to the blood pressure, the objective findings following operation may be stated as follows: Morbid changes in the eyegrounds when present before operation quite generally disappeared. Relaxation of constricted retinal vessels, absorption of exudates and hemorrhages and reduction in the grade, or disappearance of papilledema was noted, not in all, but in many instances. The heart, as measured in preoperative and postoperative roentgenograms decreased in size after operation in a number of cases in which it was enlarged previous to operation. The renal function present before operation was not changed as a result of the operation.

The supposed untoward effects of the operation which might give rise to disabilities after operation have, thus far, in our experience been of very little significance. The paralysis of the abdominal muscles, the result of the section of the motor roots, was expected to give rise to a protuberant abdomen. While enlargement of the abdomen has occurred, it has been neither unsightly nor disabling. On the other hand, it has been observed that the blood pressure after operation in some cases is higher in the prone than in

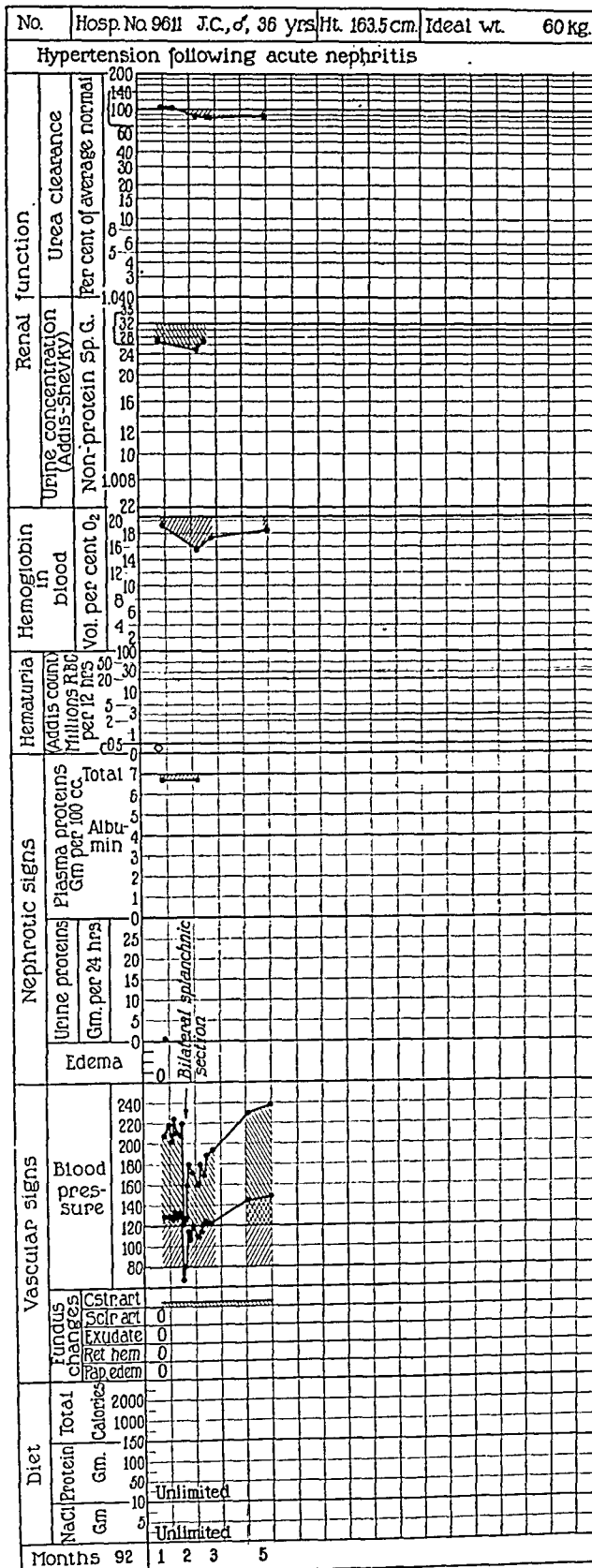


CHART 2.—Effects of splanchnic nerve resection. The blood pressure, reduced immediately after operation, has returned to its preoperative level. This has been our experience in nine cases subjected to this operation.

the erect posture, and it may be that relaxation of the abdomen is a factor in the lowering of the blood pressure. The loss of sweating of the skin of the trunk from the xiphoid or costal margin to the symphysis pubis has not been noticed by patients. The difficulty in evacuating bladder and bowel due to the loss of function of the abdominal muscles has disappeared, as a rule, within 48 or 72 hours. The supposed danger of failure of kidney function due to the fall in blood pressure was not anticipated by us and has not been realized. The blood flow through the kidney is maintained satisfactorily with a lowered blood pressure, and Doctor Page's postoperative studies show that the urea clearance and the ability to concentrate urine are practically unaffected by operation.

The serious danger in the operation is the occurrence of a lesion of the cord giving rise to paresis or paralysis of the lower extremities, bladder and rectum. The nature of the lesion in our case and its cause remain for the moment undetermined. That the lesion could have been due to cord compression the result of a blood clot in the wound seems doubtful; that it was not due to operative trauma of the cord seems proven by our careful examination of the cord; that it was not due to operative interference with the blood supply of the cord also seems clear. The possible occurrence of this complication seems to us a very strong objection to the procedure.

Our experience with the operation of splanchnic nerve resection combined with removal of the lower thoracic sympathetic ganglia can be stated very briefly. The operation in one or two stages has been performed thus far on nine patients and in all, except one instance, was carried out on both sides. In the selection of patients for this operation, seven of the nine cases had mild benign hypertension and two had malignant hypertension; the majority, therefore, were those in whom a favorable result might be anticipated. The same prolonged, careful and comprehensive observations have been made before and after operation as in the patients subjected to anterior root section. The results in the nine cases have been disappointing. In all, the blood pressure, reduced as a result of the operation, promptly rose to its preoperative level and for periods of six months to one year either has continued at this level or has become more elevated (Chart 2). The results from the viewpoint of the relief of subjective symptoms also have been minimal. So far as our experience goes, therefore, this procedure has failed to give results comparable with those of anterior root section; it is, however, realized that the number of cases thus far subjected to this procedure is too small from which to draw definite conclusions.

DISCUSSION.—DR. GEORGE W. CRILE (Cleveland, Ohio).—This paper is distinctly a Heuer type of paper, careful and logical. For my part may I present a slightly different approach.

Let us take a view of the background, the possible source or genesis of hypertension. Figure 1 shows the adrenal gland and the sympathetic system in an alligator of about the same weight as a full grown lion or tiger. It

has no sympathetic complex whatever. Sympathin is a product of the sympathetic nervous system, which was discovered by T. R. Elliott, and has been found to function like adrenalin; that is, it instantaneously speeds oxidation, its effects spreading over the whole sympathetic system. If that be true,

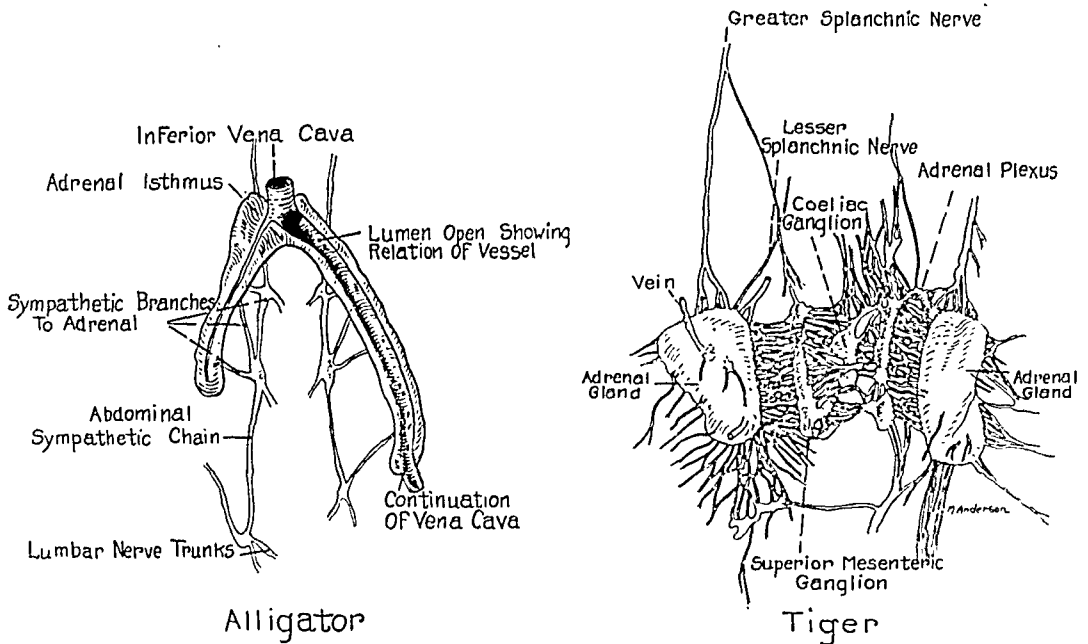


FIG. 1.—Adrenal sympathetic system of alligator. FIG. 2.—Adrenal sympathetic system of tiger.

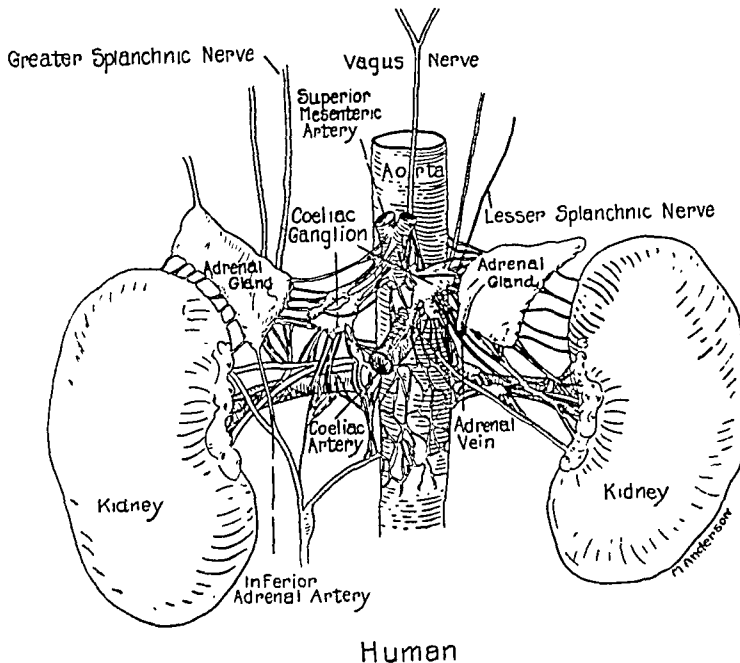


FIG. 3.—Human sympathetic system.

then those animals requiring great outbursts of activity should, in contradistinction to this slow and lazy alligator, have a great complex here. This contrast is exhibited in Figure 2, which shows the adrenal sympathetic system in a tiger of approximately the same weight as that of the alligator whose lack of a sympathetic complex we have just shown. Look at the enormous

development of the sympathetic complex, the numbers of unnamed ganglia present, like a cluster of grapes, and the size of the complex itself. Eighty-one fibers enter the adrenal gland in this powerful animal which shows the greatest power in its immediate outbursts of energy.

Figure 3 shows the human adrenal sympathetic complex. When we denervated the adrenal glands, we could cure hyperthyroidism and neurocirculatory asthenia. We could abate essential hypertension in some cases but in many cases we failed to do so and so we were dissatisfied. As the results of our clinical experience and our findings in animals during the last six months, we have concluded that there are at least two separate functions of this great energy system. One is that of driving—speeding the oxidation in the animal. That is clear enough. The other is a drive on the circulation,

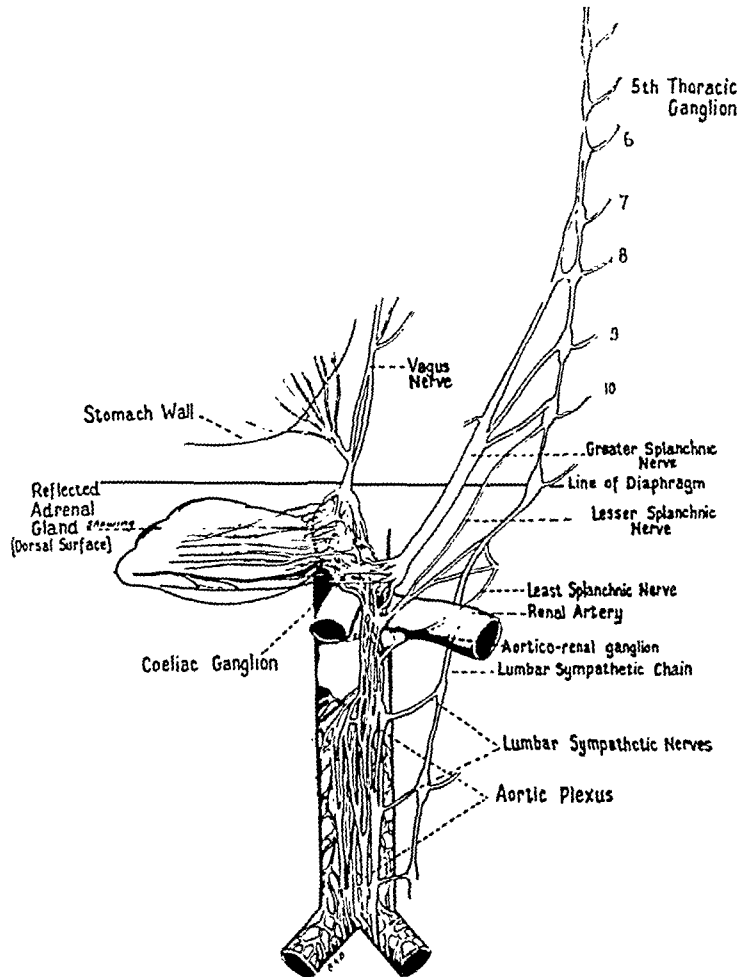


FIG. 4.—Sympathetic nerves on surface of aorta.

to carry an increased supply of oxygen through the blood stream. And to accomplish this we have a concentration of lines of communication on the aorta, some actually entering into its walls. There are similar communications with the whole arterial tree, the capillaries alone, according to Crowe, amounting in length to about 150 miles. We therefore changed our point of view, and in the treatment of hypertension attacked only the lines of communication of this energy system with the arterial tree.

Figure 4 shows the denervation of the aorta, from the bifurcation to the crus of the diaphragm. We also break up the coeliac plexus and take out the coeliac ganglia. This is a complete denervation, so far as the artery is concerned and that is all we need to think about in essential hypertension. One can see how inadequate it is just to denervate the adrenals and divide the

splanchnic nerves. Our attack should be solely upon the energy that causes the contraction of this great arterial tree.

A universal Raynaud's disease is probably what essential hypertension is. If that is true, then this procedure should produce an immediate effect, an immediate fall of the blood pressure. As the result of this operation, there is a more definite immediate fall in the blood pressure, especially in the diastolic pressure, and the hypertension is more definitely relieved. For the final end-results we must await the confirmation of time.

DR. ALFRED ADSON (Rochester, Minn.).—I do not think there is a great deal to add after Doctor Heuer has given his thorough discussion and Doctor Crile his contribution to the subject. However, my interest in the subject has been carried along for a number of years; perhaps I might add one or two points relative to the selection of patients for sympathectomy and relative to the choice of operation.

I wish that it were possible always to prognosticate definitely, preoperatively, which patients are suitable for, and which are going to respond to, extensive sympathectomy. All of us who have been carrying out these operations, I am sure, have had this experience: we have advised operation and have performed it upon a patient whom we though should respond favorably, only to be disappointed and see the pressure rise and the symptoms return at a later date. Equally true, we have accepted a patient for operation rather reluctantly because of marked retinitis and changes resulting from high pressure and have found, to our surprise, that the patient made remarkable improvement following operation.

I want to emphasize what Doctor Heuer called attention to, and that is the preoperative studies, because it is very evident that if there has been irreparable damage to the heart, kidneys, retinae and cerebral vessels, little is to be expected from operative interference.

I had observed early in the series that whenever a patient's blood pressure dropped, as Doctor Crile illustrated on his chart, following thorough anesthetization before operation, that patient was the one who responded most favorably and received the best results. Doctor Allen, who has taken Dr. George Brown's place in the section on vascular disease, took the cue and has carried out a number of studies, such as Doctor Heuer has referred to, with reference to the drop in pressure during rest and under the influence of barbiturates; but Doctor Allen carried it one step farther. He had these patients anesthetized with a barbiturate, such as pentothal sodium, or an amytal, and frequently found that the systolic blood pressure would drop to 130 or 120 Mm. of mercury and even as low as 100. During the ten minutes of anesthesia the diastolic pressures also fell to less than 100 Mm. of mercury.

In comparing the preoperative and postoperative changes, Doctor Allen found that preoperative drops in pressure corresponded to the postoperative pressures. It appears that the anesthesia test is one that may help in selecting suitable cases. Even though there are no evidences of irreparable damage in the kidneys or heart, there may be present a fixed change in the arterial wall which will not allow vasodilatation. Therefore negative renal function and blood tests are not necessarily assurances that the patient will respond to extensive sympathectomy.

The object of the operation, as Doctor Heuer has told us, has been to denervate a large vascular area, below the diaphragm, and to thoroughly denervate the suprarenal gland high, at the source of its innervation. Perhaps the most radical and most effective operation is extensive rhizotomy, because then the sympathetic fibers are divided as they leave the spinal cord. The

operation Doctor Peet has been performing is a much simpler and less extensive procedure. It does not include the rami to the upper two lumbar ganglia and only occasionally the rami from the twelfth dorsal root.

We have had two cases such as Doctor Heuer referred to; that is, transverse myelitis which developed following extensive rhizotomy. This led to the development of the subdiaphragmatic procedure, since the supradiaphragmatic operation did not include as many sympathetic fibers as I wanted to divide.

In developing the subdiaphragmatic procedure, it occurred to me that if it were possible to resect all three splanchnic nerves, major, minor and lesser, on both sides, and if it were possible to take out the first and second lumbar ganglia, I would then interrupt all of the sympathetic fibers carrying vasoconstrictive impulses to vessels below the diaphragm, just as is accomplished in rhizotomy. Therefore, I have discontinued rhizotomy and have employed the subdiaphragmatic operation. To date, we have carried out the procedure on 25 patients, operating first on one side, and ten days later on the opposite side.

In view of the experiences that other men have had with the suprarenal gland, and in the light of Doctor Crile's work on denervation, I included biopsy of the suprarenal gland in the first case, but in the others I included half of each suprarenal gland. I am not sure that this is necessary.

In our group of cases in which rhizotomy has been performed, I should say the results are poorer than those that Doctor Heuer has reported. This may be attributable to the fact that in our early experience we had no guide for accepting cases except trial and error. The group of cases in which rhizotomy was performed numbered 27, with two deaths. One patient died from a suprarenal tumor; one from meningitis. Thirteen patients obtained satisfactory results. In the series in which the subdiaphragmatic operation was performed, there were 25 cases with no postoperative deaths, nor has there been a death since operation. The first patient was operated upon in February, 1935. Three patients in this group have not responded well, since the pressures have returned to preoperative levels, while the pressures of others have dropped so low that it has been necessary to apply an abdominal binder.

I believe the subdiaphragmatic operation is just as effective in interrupting vasoconstrictor impulses as is rhizotomy, and it is possible that the operation may be more effective in that we are interrupting postganglionic rami instead of preganglionic fibers.

DR. DALLAS B. PHEMISTER (Chicago, Ill.).—In general, the excision of normal structures, with obliteration of normal physiologic processes, should not cure disease as does excision of pathologic tissue obliterating a pathologico-physiologic process. We do not know but that the nerves excised or divided in these operations may be normal, and that is what makes it so difficult to determine what the effect is going to be upon the pathologic physiology.

I thought you might be interested in some experiments that Dr. Kieth Grimson has carried out with me, in which normal dogs were operated upon: excising the entire thoracolumbar chain on both sides, and then studying the blood pressure at frequent intervals by the arterial puncture technic, over long periods of time. After the first operation, *i.e.*, excision of the thoracic chain on the right side, a fall in blood pressure occurred; excision of the left side was then undertaken, followed by excision of the abdominal portion at one operation. The blood pressure remained low for a variable number of

days, ranging from 75 to 150; climbed gradually, and in 150 to 250 days, as a rule, was back to normal. In 430 days the pressure was practically the same as it was before the operation.

Autopsies have been performed upon some of these dogs, and there have been no evidences of restoration of the sympathetic chain. It is difficult to know whether there are fibers that have grown in and reestablished connections that cannot be identified grossly.

The same operation that Doctor Heuer has performed upon a patient, and also the Peet operation, was carried out upon dogs. In those cases, in both instances, there was a very rapid return of the blood pressure to normal. Four other dogs, operated upon by the method of Doctor Heuer, had a return of their blood pressure level in from 10 to 30 days.

These findings might be regarded as a discordant note in the surgical treatment of essential hypertension, but again I want to emphasize that the results obtained from surgery upon a normal dog are not comparable with results obtained, from the same operation, upon a sick patient.

THE DEMONSTRATION OF HORMONES IN TUMORS*

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THE isolation of the pituitary and ovarian hormones has opened up new fields of experimental investigation as to the causes and processes of normal and pathologic growth. The significance of some of the results of these investigations is not yet understood. Herewith is recorded the results of bio-assays of the tissue of a number of different tumors. It was thought, in the beginning of this investigation of the hormones, that if the tissue changes associated with cystic disease of the breast and benign tumors were due to the ovarian hormones, these might, or probably could, be recovered from the tissue affected on bio-assay.

The effects of hormonal stimulation in normal development are generalized. A group of organs responds in a correlated manner to a given level of secretion and in a single organ all of the tissues composing it tend to respond to the same degree. This is quite different from tumor growth in which a single component in a localized focus of tissue exceeds in growth and amount the surrounding tissue in the remainder of the organ. However, it has been demonstrated by means of bio-assay that such a focus of actively growing cells may respond selectively and excessively to a biochemical stimulus of a hormone which usually is uniformly distributed in the blood.

Lewis and Geschickter²⁴ reported a localized concentration of the ovarian hormone, estrin, in a benign breast tumor (fibroadenoma) removed at operation, and showed that injections of this estrogenic hormone into monkeys produced hypertrophy of the breast. Extending this method of biochemical study to other human tumors, it has been shown that hormones secreted by the pituitary gland and the ovaries may be recovered in high concentrations from a variety of benign and malignant tumors. The method of assay consists of grinding up the freshly excised tumor and extracting the finely divided tissues with suitable solvents. The substances recovered by extraction are then injected into rats, mice or rabbits and the presence and amount of the hormones present determined by the effects on the sexual organs of the animals used for testing. These studies reveal that when high or normal levels of endocrine secretion are present in the blood or urine of patients, the tumor may contain excessive amounts of hormones probably concentrated locally by the growing tissues.

The presence in growing tissues of high concentrations of hormones has

* Aided by a grant from the Anna Fuller Fund.

but recently been demonstrated. Such concentrations had been found only in the tumors of organs which are normally endocrine in nature (organs which elaborate the hormone locally) such as the testicle, ovary or placenta. In the present studies such concentrations have been found in tumors of non-endocrine organs such as the breast, uterus, and bone.

HORMONE STUDIES OF BREAST TUMORS.—Castration was suggested as a treatment of carcinoma of the breast in women before the menopause by Beatson,⁴ in 1896. He thought that castration caused fatty degeneration and death of the cancer cell. A few striking results were obtained in cancer by castration, but because of the number of failures and the higher percentage of cancer of the breast occurring after the menopause, this method of treatment was abandoned. In 1919, Loeb²⁶ came to the conclusion that the inci-



FIG. 1.—Photograph of a girl, aged five, with enlargement of the breast and nipple following the injection of 6,000 rat units of estrin. The circles mark the limit of mammary enlargement.

dence of spontaneous cancer of the breast in inbred strains of mice could be reduced and ultimately prevented, if castration was carried out at progressively early stages in female mice. Loeb raised the question as to whether the relation of hormones to the development of cancer is specific, and whether a hormone influences the development of cancer only in those organs to which, under normal conditions, it has a definite relation. Cori,¹⁰ in 1927, and Murray,²⁸ in 1928, supplied experimental evidence demonstrating that the ovaries and their endocrine secretions were of primary importance in raising breasts to the physiologic threshold where susceptibility to mammary carcinoma occurred in strains of mice susceptible to

cancer of this organ.

A specific relationship between ovarian hormones and cancer of the breast, however, was not demonstrated until after the isolation of the ovarian hormone, folliculin or estrin, by Allen and Doisy¹ and other investigators. Lacassagne,²² in 1932, demonstrated that injections of estrin caused carcinoma of the breast in male mice which otherwise remained cancer free, although the females of the same strain were susceptible to cancer of the breast. Lacassagne,^{21, 23} in 1934, also found estrin in colostrum secreted from the breast of a woman with mammary carcinoma.

Virginal Hypertrophy, Gynecomastia and Fibro-Adenoma.—Enlargement of the breast associated with granulosa cell tumors of the ovary and high levels of estrin secretion have been repeatedly reported in the literature. Fig. 1 illustrates the action of estrin on the breast of a girl, aged five, who had received injections amounting to 6,000 rat units of estrin over a period of six

weeks in the treatment of gonorrheal vaginitis (Fig. 1). Apparently the tremendous hypertrophy of the breast observed at puberty (virginal hypertrophy) in certain women is due to increased secretion of estrin. In the one case in which we have had an opportunity to make an assay of the blood 25 rat units of estrin per liter were recovered.

Gynecomastia occurs in 5 per cent of the cases of teratoma testis. Lilienthal²⁵ has reported a striking case associated with chorio-epithelioma arising apparently in a mediastinal teratoma and accompanied by a positive Aschheim-Zondek test. In addition to the high concentration of the prolan found in the urine, both Heidrich and Hamberger have reported high concentrations of estrin in men suffering from gynecomastia and testicular tumors. We have demonstrated experimentally that mammary hypertrophy can be produced in male monkeys either through the direct action of estrin or indirectly by injections of prolan, the testicles being present. Moreover, in a case of gynecomastia occurring in a man of 22, we have demonstrated increased concentrations of estrin in the blood (10 rat units per liter) in the absence of any testicular neoplasm. In two other cases of gynecomastia, uncomplicated by testicular tumors, 200 and 2,500 rat units of estrin per kilogram have been recovered from the excised breast tissue.

TABLE I
BIO-ASSAYS FOR ESTRIN AND GONADOTROPIC SUBSTANCE IN FIBRO-ADENOMA,
GYNECOMASTIA, INTRACANALICULAR MYXOMA, AND FIBROSARCOMA OF BREAST*

Subject	Estrin (Rat Units per Kilo)	Gonadotropic Substance (Rat Units per Kilo)
Rat: Control breasts.....	Negative	†
Rat: Fibro-adenoma.....	2,000	—
Rat: Fibrosarcoma.....	1,000	—
C. F. 19 Control breast.....	Negative	—
Menopause Control breast.....	Negative	—
B. Fibromyxoma.....	Negative	60,000
C. Fibromyxoma.....	200	—
C. Forro-adenoma.....	1,000	—
L. Fibro-adenoma.....	200	2,500
J. Fibro-adenoma.....	6,000	—
D. Fibro-adenoma.....	12,000	—
Co. Fibro-adenoma.....	2,000	—
Ba. Fibro-adenoma.....	18,000	—
Ku. Fibro-adenoma.....	250	—
M. Gynecomastia.....	200	Negative
K. Gynecomastia.....	2,500	Negative

* Tissues fixed in 95 per cent alcohol.

† Not done.

The localized tumors of the breast, such as fibro-adenomata, have a microscopic structure similar to that seen in diffuse virginal hypertrophy. In the belief that concentrations of estrin would be physiologically significant for the tumor growths we have assayed such tumors removed at operation. These assays show that the concentration of estrin may be as high as 18,000 rat units per kilogram. Giant fibromyxomata of the breast have also been assayed. These assays not only showed high concentrations of estrin but also as many as 60,000 rat units of gonadotropic substance per kilo (Tables I and II).

TABLE II

ASSAYS OF BLOOD AND URINE IN VIRGINAL HYPERTROPHY AND GYNECOMASTIA

Diagnosis	Estrin Rat Units per Liter	Gonadotropic Substance Rat Units per Liter
Gynecomastia (S).....	Blood—Negative	Urine—Negative
Gynecomastia (K).....	Blood—Negative	Urine—Negative
Gynecomastia (L).....	Blood—25	Urine—Negative
Gynecomastia (W)*.....	Blood—Positive	Urine—40,000
Infantile hypertrophy (H).....	Blood—Not done	Urine—Positive
Virginal hypertrophy (LKY).....	Blood—25	Urine—Not done

*Associated with Teratoma Testic

Cystic Disease of the Breast.—In cystic disease of the breast there is an increase in the fibrous elements, and hyperplasia of the duct epithelium with dilatation of the ducts and cyst formation. Experimentally—cystic changes may be produced in the breast by the injection of estrin—and changes simulating lactation by the use of prolactin (Geschickter and Lewis).¹⁴ It would seem that in cystic disease the combined effects of estrin and prolactin stimulation were represented. The assays of the tissue and cyst fluid, from the breast of patients with cystic disease, have revealed high concentrations of both estrin and prolactin (the lactogenic substance of the anterior pituitary) (Table III).

TABLE III

ASSAYS OF TISSUE AND FLUID FROM PATIENTS WITH CYSTIC DISEASE OF THE BREAST FOR LACTOGENIC AND ESTROGENIC SUBSTANCES

Specimen	Patient	Hormone Assayed	Results of Bio-Assay Bird Units per Liter
Cyst fluid*	S. K.....	Lactogenic substance	2,000
	L. F.....	Lactogenic substance	720
	Bur.....	Lactogenic substance	0
	Jar.....	Lactogenic substance	250
	Car.....	Lactogenic substance	100
	Gar.....	Lactogenic substance	750
	N. W.....	Lactogenic substance	250
	Grom.....	Lactogenic substance	250
	Wei.....	Lactogenic substance	400

TABLE III—Continued

Specimen	Patient	Hormone Assayed	Results of Bio-Assay Bird Units per Liter
			Rat Units per Liter
Cyst fluid†	B. C.‡	Estrogenic substance	6,000
	Jar.	Estrogenic substance	0
	Car.	Estrogenic substance	2,000
	Gar.	Estrogenic substance	0
	N. W.	Estrogenic substance	0
	Joh.	Estrogenic substance	1,000
			Rat Units per Kilogram
Mammary Tissue	N. B.	Estrogenic substance	6,000
	R. C.	Estrogenic substance	1,000
	P. D.	Estrogenic substance	200
	I. D.	Estrogenic substance	4,000
	Bro.	Estrogenic substance	0
	A. L.	Estrogenic substance	0
	Bur.	Estrogenic substance	0
(Adenosis)	D.	Estrogenic substance	200

* Tested by the response in the crops of pigeons (Riddle test).
† Tested by vaginal smear in castrated rats (Allen-Doisy test).
‡ Fluid was removed from cysts of both breasts of this patient. The milky fluid from the right breast contained 6,000 rat units of estrogenic substance per liter. The yellow turbid fluid from the left breast did not contain any estrogenic substance.

Although the experiments of Loeb and Lacassagne would seem to indicate that estrin may play a rôle in the formation of carcinoma of the breast in mice, bio-assays for estrin in the tissue of mammary carcinoma removed from patients have yielded no strikingly positive results. The majority of cases assayed to date have proved negative (Table IV).

ENDOCRINE STUDIES IN UTERINE MYOMATA.—Myomata of the uterus and endometrial hyperplasia are associated with ovarian tumors of the granulosa cell type. In over 125 granulosa cell tumors of the ovary appearing in the literature, endometrial hyperplasia, thickening of the musculature or the occurrence of adenomata or adenomyomata have been common (Stefancsik²⁰). In such cases increased blood levels of estrin and an increased urinary output of the same hormone have been reported. When estrin has been injected in rabbits it has been noted frequently that the musculature of the uterine horns has been doubled or trebled in thickness as a result. Bearing this in mind we have assayed myomata of the uterus for estrin (Table V). The high concentration (11,000 rat units per kilo) of prolan, or a pituitary-like sex hormone present in some of these tumors, would seem to indicate that this hormone may play a synergistic rôle in stimulating the musculature.

TABLE IV

BIO-ASSAYS OF ESTRIN, PROGESTIN, AND GONADOTROPIC SUBSTANCE IN CANCER
OF THE BREAST

Patient	Age	Diagnosis	Hormone Assayed	Result of Bio-Assay (Rat Units per Kilo)
M. H.....	50	Adenocarcinoma	Prolan	Negative
			Estrin	Negative
R. L.....	43	Scirrhus	Progestin	Negative
C. C.....	50	Scirrhus	Progestin	Negative
			Estrin	Negative
L. L.....	65	Colloid	Estrin	Negative
M. L.*.....	37	Scirrhus	Estrin	Negative
G. K.....	36	Scirrhus	Estrin	2,500
			Prolan	Negative
D. B.....	51	Infiltrating duct ca.	Estrin	Negative
E. S.†.....	32	Grade IV carcinoma	Estrin	850
			Prolan	7,000
B. B.†.....	47	Grade IV carcinoma	Estrin	850
			Prolan	Negative
M. C.†.....	65	Papillary	Estrin	Negative
			Prolan	Negative
CAR.†.....	45	Papillary	Estrin	Negative‡
			Prolan	Negative
C. C.....		Papillary	Estrin	2,500
M.....		Papillary	Prolan	6,000

* Virginal hypertrophy with cancer. Blood positive for estrin on seventh day of period.

† Checked by Doctor Morrell.

‡ Positive for estrin on direct injection of tissue.

TABLE V

BIO-ASSAYS OF ESTRIN AND GONADOTROPIC SUBSTANCE OF MYOMATA
OF THE UTERUS

Patient	Estrin (Rat Units per Kilo)	Gonadotropic Substance (Rat Units per Kilo)
Control normal		
Premenstrual uterus..	3,000	
P.....	4,000	4,500
J.....	1,000	11,000
G.....	Negative	Negative
T.....	Negative	Negative
R.....	600	11,000
D.....	200	—*
O.....	30,000	—*
J.....	600	—
B.....	600	—
O.....	600	—
B.....	250	—
K.....	Negative	—
J.....	Negative	—

* Not done.

STUDIES OF THE OCCURRENCE OF PARATHORMONE IN GIANT CELL TUMORS.—Erdheim,¹² in 1907 called attention to changes in the bones associated with parathyroid adenoma. Mandl,²⁷ in 1926, conclusively proved the endocrine basis underlying tumors and cysts found in von Recklinghausen's disease. He removed a parathyroid adenoma and obtained clinical improvement in a case of multiple osteitis fibrosa cystica. Since this date many contributions (Hunter,²⁰ Ballin and Morse,³ etc.) have emphasized the endocrinological factor in this disease.

While hyperparathyroidism, with an elevation of blood calcium is an etiological factor in von Recklinghausen's disease, no parathyroid changes nor increase of blood levels of calcium or parathormone have been found in solitary giant cell tumor or solitary bone cysts. Repeated determinations of calcium and phosphorus in the blood serum of patients with solitary giant cell tumors and bone cysts have been made in this clinic and elsewhere. However, nothing has been found which would indicate a state of hyperparathyroidism.

However, giant cell tumors may occasionally occur in the latter third of pregnancy. We have seen several instances in the long bones. Epulis of the alveolar margin, developing during pregnancy, is a well recognized clinical variety of giant cell tumor. Hamilton¹⁸ has demonstrated that the parathormone output is increased during pregnancy. In several instances of giant cell tumor occurring in patients between 39 and 60 years of age, the long bones in the unaffected extremity showed a visible epiphyseal line. These findings suggest a possible disturbance in bone metabolism as a factor in the development of solitary giant cell tumor. The possibility that a localized increase in the concentration of parathormone may occur at the site where the tumor develops has led us to attempt the bio-assay of solitary giant cell tumor for parathormone. Two cases treated by preoperative irradiation gave negative results.

Three additional benign giant cell tumors treated by primary curettement gave positive bio-assays for parathormone. Dogs weighing approximately 10 kilograms were injected with the equivalent of 4 to 8 grams of tumor tissue, and showed an increase of 18 to 22 per cent in their blood calcium 15 hours after the initial injection.

The tumor tissue was extracted in 5 per cent hydrochloric acid in a boiling water bath for 45 minutes (Collip⁸). The digested material was diluted with four parts of hot water and subsequently chilled to remove the fat. The liquid was then raised to a P_H 8 to 9 with sodium hydroxide. Five per cent hydrochloric acid was added slowly until a precipitate occurred (at about P_H 5.5). The material was then filtered, saving both filtrate and precipitate. The precipitate was again made alkaline and again precipitated as above. This process was repeated three times. The hormone was then recovered from the free filtrate by making the solution acid to congo red and then

saturating with sodium chloride. The flocculent, active material was then separated and dissolved in weak sodium hydroxide, and the liquid adjusted to P_H 4.8. The precipitate was centrifuged and the supernatant liquid was treated as above. The precipitates were then added together and dissolved in a weak hydrochloric acid solution at P_H 3. This active solution was injected into the dog after being neutralized just before injection.

Table VI shows the results of assays on parathormone in giant cell tumors and in a case of osteolytic sarcoma, occurring three and one-half years after curettage and irradiation for benign giant cell tumor. In addition, assays for growth hormone and gonadotropic substance in benign osteochondroma and osteogenic sarcoma are recorded.

TABLE VI

BIO-ASSAY OF PARATHORMONE, GROWTH AND GONADOTROPIC HORMONE IN BONE TUMORS

Patient	Diagnosis	Hormone Assayed	Result	Units per Kilo Dry Weight
J. C. B.... 2-15-35	Giant cell tumor (irradiated)	Parathormone	Negative	0
Monroe.... 9-11-35	Giant cell tumor (irradiated)	Parathormone	Negative	0
Henry..... 1-21-36	Giant cell tumor	Parathormone	Positive	25,000
Irwin..... 3-11-36	Giant cell tumor	Parathormone	Positive	14,000
Mentzner.. 7-29-36	Giant cell tumor	Parathormone	Positive	14,000
Brown.... 10-11-34	Sclerosing osteogenic sarcoma (irradiated)	Growth hormone Gonadotropic hormone	Positive Positive	65 4,500
Ewing..... 3-11-36	Osteolytic sarcoma	Parathormone	Positive	25,000
Harper.... 4-10-35	Osteochondroma	Growth hormone	Negative	0

CONCLUSIONS

No conclusions are to be drawn from the results of these bio-assays regarding the causal relationship between the hormones and tumor formation. In certain benign lesions of the breast, such as cystic disease and fibroadenomata, these hormones may be recovered in a high percentage of cases, while they are inconstant, or absent, in carcinoma of the breast. On the other hand, the methods in use for extracting hormones from tissue do not neces-

sarily yield the total amount of active substance from the tissue. It has been shown, particularly in regard to estrogenic substances, that various methods of extraction will yield different quantitative results or a variety of active fractions. Preliminary hydrolysis of the tissue with hydrochloric acid or injection of an emulsion of freshly ground tissue (when not too toxic) may give higher values than the routine method of hot alcoholic extraction.

The exact composition of the hormone, its source and its ultimate fate in the body, often remains in doubt after repeated assay of the tissues, blood and urine in a given case. While the structural formula for the female sex hormone is known (ketohydroxyestrin and trihydroxyestrin), estrogenic activity has been demonstrated for a series of condensed ring compounds of similar structures which are closely related to the sterols and bile acids (Cook, Dodds and others⁹). Hence no conclusion regarding the chemical identity of the substance can be drawn from bio-assay. A varied group of substances likewise may produce the Aschheim-Zondek² reaction.

The above assays are merely recorded as facts and any attempt at interpretation must await the results of further investigation. The presence of these endocrine substances in new growths would seem, however, to have significance in the physiology of the growth and to explain more satisfactorily, than any theory yet advanced, why tissues in a new growth reproduce themselves locally, and in metastases.

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DISCUSSION.—DR. CHARLES CARROLL LUND (Boston, Mass.).—It is noteworthy to have as busy a surgeon as Doctor Lewis take an interest in chemistry and hormones, and I think it has an important bearing on the surgery of the future.

It might be of interest to know that in the recent general examination at the Harvard Medical School, the men were given great latitude in the choice of writing a paper, in a four hour test. They were given three hours of the four to write on any subject in medicine they wanted to, in which there had been recent advances. Three-quarters of the class elected some phase of endocrinology. It is obvious, therefore, that this is one of the fields the present student is interested in.

Doctor Lewis, wisely, does not draw any conclusions from his observations. The field is opening up so rapidly that the first thing of importance is to collect relevant data, and certainly the essayist has made noteworthy advances in the subjects considered.

There has been considerable discussion concerning these hormones being important as an etiologic factor of breast cancer. Gardner and Allen in New Haven, and others, have shown that there are at least three hormones

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important in the development of the breast, the gonadotropic, estrin, and progestin, and in addition there is the prolactin, which is important in secretion. I think the conservative point of view to take about the animal experiments of Lacassagne and others, at present, is not to attribute to estrin, or any other hormone, the cause of cancer in male breasts or in breasts of castrated animals, but simply to consider that if you are going to have cancer in a breast you have to have breast tissue. On a quantitative basis, roughly, in the human male and female, you get about as much cancer in the male breast per gram of tissue as you do in the female breast. So that it may not be hyperestrinism, or any endocrine deficiency, but simply the number of cells that are exposed by time to other processes which cause cancer of the breast.

MEMOIR

EDWARD STARR JUDD

1878-1935

SINCE this Association last met surgery has sustained a heavy loss—Dr. Edward Starr Judd passed away on November 29, 1935, after a short illness. An intimate friend of all of us, his loss is an extremely personal one.



EDWARD STARR JUDD, M.D.

We all recognized his loyalty to friends and the principles for which he stood. He inspired confidence and imparted wisdom in discussions and in those matters in which he was called to make a decision. Shy in manner, but forceful in action, he was often the arbiter in discussion. His surgical

ability was universally recognized. Possessed of rare technical ability, an exceptionally keen diagnostic sense and unusual surgical judgment, which in most instances seems to be a gift rather than an acquisition, he had the mental equipment and manual dexterity of a Master Surgeon.

Anything that might be said on this occasion would be inadequate, knowing him as we did, to emphasize the greatness of the man. Record should be made of his accomplishments for the oncoming surgeons, so that they may know of the course he pursued in the development of those talents which were given him and of his contributions to organized medicine and surgery.

He was born in Rochester, Minnesota, on July 11, 1878, and was graduated from the University of Minnesota School of Medicine in 1902. After serving an internship in St. Mary's Hospital at Rochester, he became an assistant of Dr. C. H. Mayo's in 1903.

He successively passed through the grades of the hospital and medical school staffs, and at the time of his death was surgeon to St. Mary's Hospital, professor of surgery in the graduate school of the University of Minnesota, and head of a section in the division of surgery at the Mayo Clinic.

Early in his professional career he became interested in organized medicine. The Minnesota State Medical Society recognized his worth and made him its president. He served as Secretary of the Section of Surgery of the American Medical Association during the period from 1913 to 1916, and chairman of the section in 1918. He was a member of the Council on Scientific Assembly from its beginning in 1915 to 1927. His sound advice was often sought in discussions concerning the organization and policies of this Council, which is an outstanding example of the value of demonstrations in the dissemination of the knowledge of newer things and the necessity of postgraduate teaching. The American Medical Association, realizing the outstanding service that he had rendered medicine, both in a professional and organizing way, made him President-Elect in 1930. In this office he served with high distinction, ever mindful of the needs of the members of this organization and the objectives which they should hope to obtain if they were to render the highest type of medical service.

Constant demands were made upon him to appear before medical societies. Facts were presented so clearly by him in such a simple but striking way that he became a postgraduate teacher of great renown. He stood on solid ground surgically and was never greatly moved by surgical fads. Having the gift of critical ability, he dealt with fundamentals. Listeners knew that he spoke with the authority of experience and strove to sit at his feet.

He was a member of the American Surgical Association, the American College of Surgeons, the Minnesota Academy of Medicine, the Minnesota Pathological Society, the Western, Southern and Interurban Surgical Associations, the American Society of Clinical Surgery and the Southern Minnesota Medical Association, and an honorary and corresponding member of several foreign surgical societies.

During the World War he was active as a teacher in the School for developing surgeons which was established at the Mayo Clinic, and from time to time since the war he has taken part in work designed to give those continuing in the Medical Corps of the United States Army a more intimate knowledge of diagnostic and operative procedures.

In 1921, Doctor Judd was made a member of the Editorial Board of the Archives of Surgery, and has served in a like capacity upon a number of other publications. His was a stabilizing influence, which few possessed. Although simple and retiring, he possessed great wisdom. His contributions to surgery were numerous, and those who practise surgery in the future will come to realize that he was responsible for many diagnostic methods and technical procedures, especially those relating to the biliary and gastro-intestinal tract. His memory will be kept alive by the works he has produced.

DEAN LEWIS

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DESTRUCTION OF THE CEREBRAL CORTEX FOLLOWING NITROUS OXIDE-OXYGEN ANESTHESIA*

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M.D., DIRECTOR.

NITROUS oxide-oxygen anesthesia is relatively safe, although fatalities have been reported by several authors. So far as we could ascertain Baldwin¹ was the first to call attention to the harmful effects of nitrous oxide. He described 14 fatalities; Caine² reported four; Davies³ one; Hahn⁴ two, and McKean Downs⁵ six cases. Caine² was the first to consider brain damage as the possible cause of death, but no histologic evidence was given by any of the above authors. We are reporting three cases in which there was destruction of the cortex and basal ganglia following the use of nitrous oxide-oxygen anesthesia and one case with clinical evidence of a similar process.

CASE REPORTS

Case 1.—R. B., white male, aged 22, was cut on the finger by a piece of metal. Treatment was begun October 24, 1932. Examination showed a small wound which would admit a grooved director. There was a slight purulent discharge and swelling of the finger. Temperature was 99.2° F., pulse 85. On October 25, under local anesthesia, the wound was enlarged and drained and the swelling subsided. On November 1 the swelling recurred and the wound was again enlarged. About 4 cc. of pus were removed and better drainage established. Nitrous oxide-oxygen anesthesia was employed for the second operation.

Twenty minutes after the beginning of the administration of anesthesia, respiration suddenly ceased and there was rigidity and tremor of the extremities. Oxygen was administered and respiration was reestablished ten minutes later, but it was forced and 40 per minute. The patient remained unconscious from that time until death. The temperature rose rapidly to 107° F. and ran a very irregular course, ranging from 103° to 107°. The pulse varied from 120 to 160, roughly following the temperature curve. The blood pressure varied between 85/60 and 125/60. All tendon reflexes disappeared permanently. There were periods of increased rigidity and tremor of the entire body when the temperature rose, but between these periods there was a lead pipe

* The material from Cases 1, 2 and 3 was sent to us for study.

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rigidity of the extremities. The muscles of mastication were hypertonic with occasional relaxation. Pupils were equal and symmetrical, varying from normal width to wide dilation, and reacted well to light. During the last eight hours the eyes were turned to the right. The margin of the right disk was obscured and the veins were engorged; the left fundus was not seen. There was incontinence of urine and feces. Laboratory findings: The spinal fluid pressure was increased but was otherwise negative. The white count was 18,000. Urine was negative. Death occurred approximately 60 hours following operation.

Postmortem Examination.—*Brain:* Leptomeninges were thin and smooth and were distinctly hyperemic. The convolutions were well developed. The basal vessels were delicate. On frontal sections the gray matter was of normal width, well demarcated and contained numerous petechial hemorrhages, especially in the occipital lobes. The basal ganglia and brain stem were hyperemic and there were few scattered small hemorrhages. Ventricles were narrow and the ependyma smooth. The cerebellum appeared normal. The remainder of the postmortem was negative.



FIG. 1.—Section of parietal cortex Nissl stain. Photomicrograph Zeiss planar 20 Mm. The third, fifth and sixth layers are destroyed. The second and fourth layers are present, but show definite degenerative changes.

Histology.—Leptomeninges were thin and showed no pathologic changes other than hyperemia.

Cortex: (Nissl stain). There was a very severe disturbance of the laminar type. The first layer contained a few scattered astrocytes; the second layer was very thin, the neurons being greatly reduced in number and those remaining were degenerated. The third layer was entirely destroyed, and contained only a few degenerated neurons. The fourth layer was better preserved and contained a considerable number of ganglion cells. The fifth and sixth layers were completely destroyed and many areas were transformed into a spongy state (Fig. 1). The cortical myeloarchitecture also showed severe changes. The tangential fibers were almost entirely destroyed, but the radial fibers were somewhat better preserved. Silver preparation showed a reduction of axis cylinders.

Basal Ganglia.—*Caudate and Putamen:* The parenchyma was severely affected, the small neurons being almost completely destroyed, but the larger ones were better preserved. There were large areas of spongy state in the putamen.

Pallidum, Thalamus and Hypothalamus: The parenchyma showed severe degenerative changes, but the cells were only moderately reduced in number.

Midbrain: In the corpora Luys, geniculate bodies, red nuclei, central gray substance and reticulate substance there was moderate degeneration of the neurons but no reduction in their number. The substantia nigra and the pons were normal.

Medulla: The neurons of the large olives were shrunk but otherwise there were no changes.

Cerebellum: The Purkinje elements were destroyed in many areas, but the granular and molecular layers were intact.

The cytologic changes of the neurons were of two types (a) shrinkage, (b) ischemic necrosis:

(a) The shrunk cells appeared small, with pyknotic nuclei and greatly reduced cytoplasm. They were devoid of tigroid substance and were frequently reduced to shadows.

(b) The ischemic elements were irregularly shaped or elongated, the cytoplasm was pale, homogeneous or slightly granular, the nuclei being stained a deep blue.

The first type was particularly frequent in the cortex, putamen and caudatum, the second in the pallidum and thalamus.

The glial response was moderate, being restricted to scattered microglia and macroglia. The blood vessels showed a slight capillary proliferation. Perivascular hemorrhages were present in some of the areas. Lipoids and iron were not present.

White matter: the oligodendroglia was increased and swollen. The blood vessels were slightly proliferated and there were scattered perivascular hemorrhages. There was no evidence of demyelination.

Case 2.—W. G., a white male, aged 28, was admitted July 1, 1934, complaining of intermittent attacks of pain in the right lower quadrant, associated with nausea and vomiting. There were no other complaints.

Operation July 2, 1934. A hyoscin-morphine-cactoid tablet No. 1 was administered hypodermically one hour before operation. Nitrous oxide-oxygen anesthesia was administered with the McKesson Nargraf apparatus. The patient had an easy induction and the anesthesia proceeded smoothly for approximately 30 minutes, when it was noted that respiration became quieter and more shallow. Oxygen was administered freely and finally under pressure. In spite of this, respiration continued to become more quiet and finally ceased. For a period of 40 minutes the patient apparently did not breathe voluntarily. Artificial respiration was continued and carbon dioxide added to the oxygen. Stimulants such as Alpha lobelin, caffeine, atropin and coramine were administered without effect. The blood pressure and the pulse rate which were normal at the beginning of the anesthesia rose to 150/90 and 120 respectively, the latter being full and of good volume. The color of the skin was pink and the patient was apparently in good condition except that he did not breathe. The pupils were moderately dilated and did not react to light, the muscles were relaxed.

After 40 minutes the patient began breathing, at first taking a few shallow breaths, which gradually became deeper. Oxygen-carbon dioxide was administered for two hours. The patient remained comatose and developed stiff neck and convulsive movements of the jaw, biting tongue and lips, and was very restless. In the afternoon his temperature rose to 105.6°, pulse to 145 and respirations to 24. Two days later he showed signs of returning consciousness and asked for water. Twitchings of the left index and third fingers were noted. About 60 hours after the operation the respirations rose to 60; the pulse became very irregular in rhythm and volume; the temperature rose to 106° and there was deep coma. Death occurred approximately 72 hours after operation. Post-mortem disclosed no gross findings of importance.

Histology.—Leptomeninges were normal. The entire cortex and the basal ganglia were severely damaged. The findings varied considerably in different areas of the cortex as follows:

(1) Areas in which all layers of the cortex with the exception of the second were destroyed, the parenchyma being reduced to a few scattered degenerated neurons.

(2) Areas in which the second and third layers were preserved while the fourth, fifth and sixth were destroyed.

(3) Areas in which the destruction was confined to the fifth and sixth layers (Fig. 2).

(4) Areas in which the destruction of the parenchyma was spotty.

Spongy state was present throughout the cortex, occurring usually in the fifth and sixth layers. The axis cylinders were considerably reduced in number. Myeloarchitectural changes corresponded to those of the first case.

Basal Ganglia: the parenchyma of caudatum, putamen, pallidum and thalamus was destroyed.

Midbrain, Hypothalamus, Medulla and Cerebellum: the changes corresponded to those in the first case. The reticulate substance showed a moderate reduction of neurons, with severe degenerative changes of the cellular structure.

Cytologic Changes: The degenerative changes of the neurons were of two types: (1) simple shrinkage, (2) ischemic degeneration with encrustations. The shrinkage

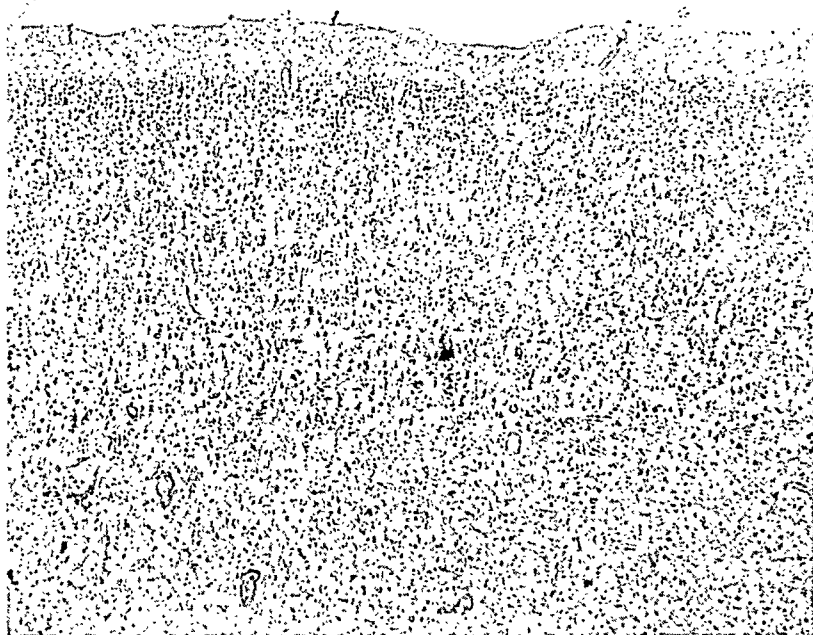


FIG. 2.—Section of parietal cortex Nissl stain. Photomicrograph Zeiss 20 Mm. The fifth and sixth layers are destroyed, the other layers show moderate diffuse degenerative changes.

corresponded to that of Case 1. The encrustations appeared in the form of numerous deep blue or black granules in the cytoplasm and on the dendrites of the cell. This change was common in the cortex but rare in the basal ganglia.

Blood vessel proliferation was marked in the basal ganglia, particularly in putamen and caudatum. There were no hyperemia or perivascular hemorrhages. Glial reaction corresponded to that of Case 1. Lipoid and iron stains were negative.

White Matter: the findings were identical with those in Case 1.

Case 3.—C. K., a white female, aged 51, admitted July 12, 1932, with complaints of menorrhagia and leukorrhea. Her health was otherwise good. General physical examination negative. Pelvic examination revealed a large, nodular mass. Diagnosis, uterine fibroid.

Operation July 13, 1932. Anesthesia was induced quietly. Panhysterectomy was performed. One hour later, while closing the wound, respiration and pulse suddenly ceased. Oxygen was given under pressure, adrenalin was injected intravenously, which effected prompt restoration of the pulse and respiration. (Time and details not mentioned.)

Following the operation the patient remained comatose and her entire body was rigid, and there was "risus sardonicus." Temperature, 100.9°; pulse, 100; respiration, 20; blood pressure, 140/80. The next morning (July 14) the temperature rose to 102.5°, the pulse to 120, but it was regular and of good volume. The patient perspired profusely. In the afternoon the respiration became very slow—eight per minute—and remained so for approximately 12 hours. The muscles of the extremities relaxed but the trunk muscles remained rigid.

During the next three days the temperature ranged between 104° to 105°, the respiration from 28 to 36, the pulse 110 to 120, blood pressure averaged 149/68. The patient continued comatose and incontinent. The entire body was rigid and there were twitchings of the left hand. On July 18 the pulse rose to 160 and became irregular; the respiration became very shallow, ranging between 32 and 40, ceasing for one to one and one-half minutes at intervals. The patient became increasingly cyanotic. The temperature rose to 106.4°. Several hours before death respiration gradually slowed down from 42 to 16 per minute. Death occurred July 19, approximately 119 hours following operation.

Postmortem revealed no gross findings of importance.

The histologic findings corresponded to those in the first two cases. The destruction involved the entire cortex and was of several types as follows:

(1) Areas in which mainly the upper layers (two and three or three and four) were damaged.

(2) Areas in which mainly the lower layers (four and six or five and six) were affected.

(3) Areas in which the entire width of the cortex was involved.

(4) Areas in which the destruction was spotty.

Spongy state was present in numerous areas.

In the basal ganglia, hypothalamus, brain stem, pons, and cerebellum no definite focal lesions were found, but the neurons showed moderate nonspecific changes.

The histologic details in the cortex and white matter corresponded to those of Cases 1 and 2.

Histologic Summary: In spite of some variation in degree the histologic picture of the three cases was essentially the same. There was severe damage throughout the cortex especially in the fifth and sixth layers (Case 2). In the first and third cases there were many areas in which the entire cortex was destroyed. The spongy state was usually restricted to the lower layers even in areas of diffuse destruction.

The damage of the basal ganglia was marked in Cases 1 and 2 and moderate in Case 3. The changes in the brain stem and cerebellum were in all cases much less severe than those of the cortex and basal ganglia. The histologic picture was purely degenerative in type.

Case 4.—J. D., white female, aged 29, admitted September 9, 1928, with a lung abscess. Phrenectomy was performed under local anesthesia with considerable improvement. The patient was discharged October 19, 1928. The symptoms recurred and the patient was readmitted November 16, 1928. The abscess was opened with cautery under local anesthesia and the cavity drained and packed with vaseline gauze. There was a rapid improvement and the patient was discharged. Eight months later the patient returned for closure of the fistula. On October 3, 1929, a bronchial and musculo-cutaneous plastic operation was performed and several large hilar bronchi were closed. The operation was conducted under nitrous oxide anesthesia, and lasted one and one-half hours.

The operation and anesthesia were without incident. During the operation the patient received 900 cc. of 5 per cent glucose per rectum and a hypodermic of morphine sulphate gr. 1/6. The patient's condition before, during and immediately after the operation was reported as fair.

In the afternoon she became restless and was given Pantopon gr. 1/3. At 8 P.M. hyoscin gr. 1/100 was given. One hour later the patient developed "spasmodic jerkings"

of the legs which soon involved both upper and lower extremities. The slightest stimulus precipitated a convulsive attack. There was fecal and urinary incontinence. The next morning, the patient was much improved and quieter but there were still slight muscular twitchings in the arms and face. The temperature was 102.6°, pulse 134, respirations 24. The head was turned to the right, but there was no rigidity of the neck. The fundi showed slight papilledema. Tendon reflexes were normal. The abdominal reflexes were absent. There was a positive Babinski on the left and a suggestion of one on the right, and the muscle tone in the legs was slightly increased. Tendo achillis pressure caused an expression of pain but no movement of the large toe. In the afternoon the patient again became noisy and restless and was given 1/100 of a grain of hyoscin. Toward the evening she was semistuporous and irrational, but answered questions at times.

During the next eight days the general condition showed a slow improvement, but on October 12 the patient was still somewhat confused and complained of impaired vision. There was a definite limitation of outward rotation of both eyes and a fine nystagmus on lateral deviation to the right. In moving the eyes upward the left eyeball lagged behind the right and went upward in jerks. Pupils were moderately dilated and did not react to light. Nasal margins of both disks were blurred, but there was no measurable elevation. Apparently there was no light perception in the right eye, but with the left she could count fingers. There was weakness of the left side of the face. The biceps and triceps reflexes were normal on the right and overactive on the left. The patient did not move the left arm and hand. When asked to squeeze with the left hand she closed the right hand. The abdominal reflexes were absent, the knee jerks were normal on the right and increased on the left. The Achilles reflexes were normal on both sides. Babinski was positive on the left, questionable on the right. There was marked sweating of both feet.

During the next few days considerable improvement was noted. The patient became oriented and emotionally stable. A slight VIth nerve palsy persisted. There was coarse tremor of the tongue on protrusion; the face was mask-like. The left arm and hand were paralyzed and there was considerable ataxia of the right arm. Knee and Achilles reflexes were normal and there was no Babinski sign on either side.

On October 22, she could count fingers at arm's length and began to move the left hand, but the ataxia on the right persisted. On October 26, the fundi were normal. Both arms were ataxic and the tone of both legs was markedly increased, more so on the right. Tendon reflexes were increased and there was an abortive ankle clonus. The umbilical reflexes were absent. On October 31, the patient complained of severe sharp pain in the hands, especially the right, associated with numbness and tingling. Strength of both hands was good, better on the right. Movements on the right were carried out better than on the left. On November 5, the patient was able to read words of ordinary print. There was some improvement of the left leg, enabling her to take a few steps. On the next day severe pain occurred in both arms and legs, more so of the left arm and right leg. Movements of the extremities accentuated the pain.

On November 9, the patient was up in a wheel chair. The extra-ocular movements and fundi were normal. The tongue protruded straight, and there was only slight weakness of the face on the left. Grip in the right hand was good but there was a marked ataxia on the right and an intention tremor on finger to nose test on both sides. There was bilateral adiadokokinesis. Grip on the left was weak. The biceps and triceps reflexes were normal. There was spasticity and increased tone of the legs and the knee and Achilles reflexes were increased bilaterally. There was bilateral ankle clonus. Vibratory sense was lost in both ankles. The sense of motion and position was lost in the toes of both feet.

By November 27, the patient was able to write legibly. Visual fields showed concentric contraction, relative central scotomata in both eyes, and later on a homonymous defect in the right inferior quadrant. The ophthalmologic symptoms improved gradually

and on January 12, 1930, the scotomata were much smaller but the fields still showed concentric contraction.

At the time of discharge from the hospital May 3, 1930, the pupils were equal, but reacted sluggishly to light. There was a slight coarse tremor of the tongue, marked ataxia on finger to nose test, which was not markedly increased by closing the eyes, bilateral adiadokokinesis, and hyperactive tendon reflexes. There was slight spasticity with atrophy of the right leg, and heel to knee to toe test was impossible on both sides. On September 8, 1930, the patient was ataxic, but was able to walk. The neurologic status was otherwise unchanged.

The patient was seen last on March 12, 1935. The pupils, extra-ocular movements, fundi and visual fields were normal. There was slight weakness of the left face with some masking. The tongue protruded straight. Biceps and triceps reflexes were exaggerated, more so on the right. Hoffmann's sign was positive on the left, the abdominal reflexes were diminished and the knee and Achilles reflexes were exaggerated. There was a suggestive bilateral Babinski and ankle clonus. There was hyperalgesia of the organic type below the sixth dorsal segment, but no other sensory changes. There was marked ataxia on finger to nose test, more marked on the left, which was increased with the eyes closed. There was a definite Romberg's sign and a tendency to fall toward the right. There was a slight spastic-ataxic gait, more marked on the left. Mentality was not materially impaired.

CLINICAL DISCUSSION.—At the present time it appears that the harmful results of nitrous oxide-oxygen anesthesia can be divided into two groups as follows: (1) Fatal cases, and (2) cases with incomplete recovery. The first group can be subdivided into (A) immediate death, and (B) those with death occurring after hours, days or weeks.

(A) Death during nitrous oxide-oxygen anesthesia has occurred following narcoses of varying duration. The shortest narcosis with a fatal result was reported by Davies³—20 seconds, in Baldwin's¹ Case 4 "just in the beginning of the narcosis," in his Case 9, after 20 minutes. McKean Downs⁵ reported a fatality after 45 minutes; Hahn⁴ reported two cases with fatal termination following an anesthesia of an hour and a quarter. In many instances the duration of the narcosis is not given, but it can be assumed that in some instances it was not long, since the anesthetic was used for minor operations as, for example, extraction of teeth.

According to all authors, in fatal cases the respiration ceases suddenly and without warning (Baldwin, Caine², Davies, McKean Downs, Hahn⁴). McKean Down states: "There was no gasping, no change in the rate or depth of respiration, no futile efforts to breathe—merely a sudden and complete respiratory failure . . ." Similarly Baldwin: "The patient died suddenly and without warning." Almost invariably the authors state that the operation progressed normally and the "color of the patient was good." Considerable cyanosis was reported only by Hahn and Davies. The respiration was restored for ten minutes in Baldwin's Case 11 following administration of artificial respiration for one hour. In all other cases failure of respiration was permanent. Death occurred in different stages of the operation with the exception of Baldwin's Case 2, who died a few minutes after the operation.

The relation of the failure of circulation to that of respiration varied in fatal cases. In McKean Downs' cases . . . "the heart continued to beat at first quite forcefully, then gradually faded out until it too stopped about one hour and a half after the breathing." Other authors reported simultaneous cessation of circulation and respiration. In Baldwin's Case 3, who was undergoing an abdominal operation, the circulation ceased instantaneously, the aorta becoming pulseless. Attempts at resuscitation with oxygen and in some cases with heart massage through the diaphragm were unavailing (Baldwin's Cases 9, 12, 13, Caine's Case 4, both of Hahn's cases).

(B) Cases with fatal outcome after hours, days or weeks. To this group belongs one case of Caine and our Cases 1, 2 and 3. The respiration ceased suddenly (Cases 1 and 3) or gradually (Case 2); but the failure of respiration was not permanent. It was reestablished after one and one-half minutes in Caine's case, after ten minutes in our Case 1 and after 40 minutes in our Cases 2 and 3. In none of these cases did respiration or circulation return to normal. The respiration was labored and 40 per minute in Case 1; it varied between 24 and 60 in Case 2; between 30 and 42 in Case 3, and between 30 and 56 in Caine's case. The pulse rate varied from 120 to 160 in Case 1; between 120 and 145 in Case 2; between 110 and 160 in Case 3, and 138 and 150 in Caine's case. The blood pressure in Cases 1 and 3 dropped slightly but soon returned to normal. There was a marked elevation of temperature in all instances: 108° (Case 1); 105° to 107° (Case 2); 106° (Case 3), and 102° to 104° (Caine). All reflexes were permanently abolished in Case 1. The reflexes were not reported in other cases. Convulsions, muscular twitchings, hypertonicity of extremities and trunk were present in all three cases. Cases 1 and 3 were comatose until death. There was a partial return of consciousness after nine hours in Caine's case and after 48 hours in Case 2. Death occurred after 17 hours (Caine), 60 hours (Case 1), 72 hours (Case 2) and 119 hours (Case 3).

In an unusual case reported by Caine, death occurred two months after anesthesia. A white woman of 58 was operated upon for chronic appendicitis and cholecystitis. Respiration and circulation ceased after 50 minutes of nitrous oxide-oxygen anesthesia. Oxygen and heart massage restored respiration and circulation one minute later. Consciousness and reflexes began to return after 45 minutes. Three hours later the patient was able to respond to questions and talked intelligently after six hours. She was apparently normal next morning but complained of seeing white balls (question of retrobulbar neuritis). Three days later the patient complained of impaired vision, but the eyegrounds were normal. A neurologist diagnosed a possible cerebral edema and considered the patient's condition to be very serious. A progressive mental deterioration developed and death occurred two months after the operation.

Group 2. Cases with incomplete recovery. To this group belongs a case reported by Caine and our Case 4. Caine's patient, a mulatto woman, aged 37, was operated upon for uterine fibroids. Respiration and pulse stopped

suddenly (time not given). Oxygen and heart massage restored the heart beat within two minutes and respiration five minutes later. Following anesthesia there was generalized paralysis, the patient was blind and unable to speak. Three years later the patient was blind, paralyzed and her speech was unintelligible. After six years she had some voluntary motion in her hands and arms and could distinguish colors and objects. Her intelligence was apparently good but the speech remained unintelligible.

Our Case 4 differs from the others in that there was no disturbance during the anesthesia, the clinical symptoms of brain damage appearing several hours after the operation. The clinical picture, however, is related to both the fatal and non-fatal cases but is less severe. She was semicomatose and greatly agitated. Convulsions, muscular twitchings, and disturbances of temperature, pulse and respiration were of the same type as in fatal cases. The paralysis was restricted to the left side and the eyesight was temporarily impaired (retrobulbar neuritis), resembling the picture described by Caine. The neurologic status varied during convalescence, tendon, reflexes and muscle tone showing frequent variations. The patient made a slow recovery and when seen five years later showed residual neurologic findings but was able to earn her living.

DISCUSSION OF PATHOLOGY.—In some of the fatal cases in which an autopsy was performed (McKean Downs, Hahn), the cause of death was not established and histologic examination of the brain was not reported. It is not likely that definite changes of the parenchyma could be demonstrated if death occurred instantaneously. Such changes can be expected only if the patient survived at least 24 to 36 hours following the anesthesia. From the neurologic findings in all three of our cases we can assume that death was due to the destruction of brain parenchyma. The two possible causes of this destruction which may be considered are: (1) asphyxia, (2) toxic effect of the gas.

The asphyxia might be produced in two ways: (*a*) anoxemia due to low oxygen content of the blood; (*b*) anoxemia due to collapse of the brain capillaries.

(*a*) The first possibility has been advocated by German authors (Flörcken⁶, Lotheisen⁷, Sudeck-Schmidt⁸) who advised the avoidance of cyanosis in the administration of nitrous oxide. This explanation is not entirely satisfactory. The significance of cyanosis is variously interpreted. According to Moore,⁹ it is not necessarily a sign of oxygen deprivation and according to Raginsky and Bourne¹⁰ a moderate degree of cyanosis cannot always be prevented. In most of the fatal cases no cyanosis was present and the color was good at all times (Case 2). There were no signs of anoxemia and the narcosis was not considered too deep. As a rule, the authors remark that both narcosis and operation progressed normally and that the fatal outcome occurred suddenly and without warning. It is not likely that signs of anoxemia were overlooked. Similarly anoxemia would not be expected to occur in 20 seconds (Davies). Anoxemia due to oxygen deprivation should

be promptly relieved by the administration of oxygen and is therefore not dangerous.

(b) Collapse of the capillaries associated with stasis and anoxemia as a responsible cause of degeneration of the parenchyma is to some extent supported by the histologic findings of Case 1, in which there were hyperemia and perivascular hemorrhages. But this change is too limited to produce a complete destruction of the cortex, and in Cases 2 and 3 it was not found. These conclusions are in agreement with the experimental observations by Gianotti and Vannotti¹¹ who studied the influence of nitrous oxide-oxygen anesthesia upon capillaries in rabbits. Under the influence of a mixture of 90 per cent nitrous oxide and 10 per cent oxygen, the entire capillary system contracted, the contraction being replaced by dilatation as soon as anesthesia was established. New capillaries appeared and the color of the underlying tissue became increasingly red. The arterioles were engorged, the speed of the blood current was reduced, the capillaries were markedly but unevenly dilated, occasionally forming aneurysms. The blood corpuscles were agglutinated and moved slowly and irregularly. Similar dilatation was also visible in the veins in which the blood flow was retarded. Perivascular and diffuse hemorrhages occurred. This condition remained without essential change even in prolonged anesthesia. Collapse of the blood vessels and complete stasis did not occur, and these manifestations could be promptly relieved by the administration of oxygen. The authors emphasized that these findings differed fundamentally from those produced by an asphyxiating mixture of nitrogen-oxygen which easily caused collapse of the vessels and stasis. They concluded therefore that the anesthetic effect of a nitrous oxide-oxygen mixture is not obtained by asphyxiation. The histologic picture suggests that the destruction of the brain is due to the toxic action of nitrous oxide on the parenchyma. A definite selective destruction is noted, the cortex and the basal ganglia being much more severely damaged than the brain stem and the cerebellum, resulting in a clinical picture of decortification. Destruction of this type is frequently a toxic manifestation and similar findings have been noted in cases of poisoning by excessive doses of pantapon, morphine and ergoapiol. Therefore, death may be due to extensive destruction of the cortex and basal ganglia rather than to involvement of the respiratory area *per se*.

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THE PHYSIOLOGY OF MASSIVE PULMONARY EMBOLISM*

AN EXPERIMENTAL STUDY OF THE CHANGES PRODUCED BY OBSTRUCTION TO
THE FLOW OF BLOOD THROUGH THE PULMONARY ARTERY AND
ITS LOBAR BRANCHES

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DESCRIPTIONS of the symptoms presented by patients with massive pulmonary embolism have usually been lacking in detail and clarity. This is probably due to the dramatic character of the event and to the usually rapid and fatal termination. Giertz and Crafoord,¹ however, have given an excellent account of the symptomatology in 27 cases. The symptoms observed in order of frequency were as follows: sudden onset of symptoms without any warning; high, soft, finally imperceptible pulse; marked pallor; unconsciousness; slight cyanosis; craving for air; dyspnea; altered respiration, superficial or deep; snatching or groaning; feeling of oppression, dread, anxiety, restlessness; pain or stitch in chest, usually over precordium; shock; cold perspiration; pulsations in veins of neck (the authors remark that this symptom is probably more frequent than was noted in the brief accounts available); waving arms about, wanting to get up. Violent vomiting, strabismus, dilated pupils, giddiness, and yawning also occasionally occur. They summarize their findings as follows: "In most instances it (massive pulmonary embolism) comes like a bolt from the blue with typical symptoms of which the most frequent are intensive pallor, loss of pulse and consciousness. Common symptoms are also oppression, craving for air and a mild cyanosis with a typical venous pulsation above the clavicles."

No adequate account of the physiologic changes underlying these varied symptoms has yet been given, although in a previous paper one of us² attempted to analyze the factors that lead to death when the main trunk of the pulmonary artery is occluded either completely or partially by a massive embolus. The complexity of the problem is increased because the obstruction to the flow of blood is usually not confined to a single point in the pulmonary arterial tree. The emboli are long and narrow and may not only produce a partial or complete occlusion of the main pulmonary artery but may extend into one or both main branches and obstruct a varying number of lobar branches.³ There results a combination of partial occlusion of the main artery and a complete block of one or more of its lobar branches. The

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disturbance produced by partial occlusion of the pulmonary artery itself obviously differs from that produced by occlusion of certain branches of that artery and a difference in symptomatology results. Valuable information on this point could be obtained by an accurate correlation of the clinical symptoms with the location of the emboli found at autopsy. Unfortunately such correlation is rare.

Smellie,⁴ however, has given a very good account of the symptoms presented by a patient with the obstruction to blood flow, incomplete but clearly confined to the main pulmonary artery. The patient, a boy ten years old, went to bed at 10 P.M. apparently perfectly well. At 1 A.M. he felt cold, and half an hour later vomited and complained of thirst. He vomited again at 3 A.M. At 5 A.M. he appeared to be asleep and breathing normally but looked pale. At 9 A.M. his general condition was the same. He did not reply when spoken to. At 10 A.M. he was breathing regularly but was very pale and could not be roused. He was taken to a hospital and died one-half hour later. At autopsy a large, firm, grayish-white clot was found in the right heart. It was firmly adherent in only one place, *i.e.*, the right auricular appendage. From this place of origin it extended through the right ventricle and terminated in each pulmonary artery just distal to the bifurcation. The thrombus was not adherent to the walls of the artery. There was an area of infarction about three inches in diameter in the lower lobe of the right lung. No other significant pathologic changes were found except some petechial hemorrhages beneath the epicardium. In this patient pallor and unconsciousness were the striking features, and except for the small area of infarction the obstruction was clearly confined to the main pulmonary artery.

Rochet,⁵ in 1930, made a clinical distinction between two types of fatal pulmonary embolism, and characterized them as "syncopale" and "asphyxique." He gives the following descriptions of each type (translated by authors):

"I found a man propped up in bed, pale as a corpse and covered with cold sweat. The pupils were dilated, respirations were intermittent and tracheal râles were present. The pulse was imperceptible and the heart sounds were infrequent and muffled. There was no cyanosis. Death occurred a few minutes later. This is the 'syncopale' type of fatal pulmonary embolism.

"My second patient was a woman, age 35, upon whom I had operated for a large fibroadenoma of the breast. . . . The postoperative course was normal for two days. On the third day the patient while moving her bowels after an enema experienced a terrific pain in the back of the chest. It was 10 A.M. . . . Symptoms of asphyxia were predominant. Respirations were shallow and rather slow. The lips were black, in sharp contrast to the leaden pallor of the face. The hands and feet were deeply cyanotic. The pulse was thready and the rate could not be determined. Auscultation of the chest revealed no abnormalities. I ordered inhalations of oxygen and an

hypodermic injection of morphine to control the severe pain in the chest. I saw the patient an hour later. She had no more pain and was almost euphoric. The respiratory rhythm was normal but the cyanosis was as intense as before, and the flickering heart action persisted, despite the use of cardiac stimulants. At 5 P.M. her condition was the same or perhaps slightly better. Death occurred suddenly at 11 P.M. This is an example of the 'asphyxique' type of fatal pulmonary embolism."

Unfortunately autopsies were not performed on these cases. Judging by Smellie's case and our own experience, it seems likely that the "syncopale" type represents an obstruction of the main pulmonary artery. The clinical descriptions are decidedly similar. The "asphyxique" type on the other hand is better interpreted as an extensive block of the peripheral branches of the pulmonary artery. Evidence substantiating these clinical observations can best be obtained by separately producing both types of obstruction to blood flow in animals and recording the physiologic changes which follow. Some experimental work on this subject has already been performed.

In 1921 Underhill⁶ noted the occurrence of anoxemia after ligating the left pulmonary artery in cats. The anoxemia was associated with some increase in pulmonary ventilation. Haggart and Walker,⁷ in 1923, noted an average increase of 26 per cent in pulmonary ventilation following ligation of an artery to one lung. This was the result of an increase in tidal air and a slight increase in respiratory rate. Binger, Brow and Branch,⁸ in 1924, produced multiple pulmonary emboli in animals by the intravenous injection of two or three hundred seeds, and noted the appearance of tachypnea and anoxemia. They concluded that the "tachypnea is due to anoxemia and can be stopped or prevented by oxygen inhalation. The anoxemia has been attributed to a change in the quantitative relation of blood flow to the vascular diffusion area in the lungs. The nature of this changed relationship is twofold: (a) an increased rate of flow through the capillaries, the flow being so rapid that the blood cannot assume its normal load of oxygen, (b) a compensatory dilatation in the capillaries which are crowded with corpuscles in columns so thick as to interfere with the normal inward diffusion of oxygen. Each of these defects in oxygen diffusion can be remedied by raising the alveolar oxygen tension." They did not attempt to determine quantitatively the diminution in the pulmonary vascular bed produced by the seed emboli.

The circulatory effects of partial occlusion of the main pulmonary artery have been studied by Gibbon, Hopkinson and Churchill.⁹ In contrast to previous work on this subject it was found that a slow fall in systemic blood pressure could be produced by compression of the pulmonary artery. The decline in blood pressure is associated with a rise in venous pressure and a decrease in cardiac output. An illustration of the fall in blood pressure accompanying a massive pulmonary embolus has been given by Churchill² in a graphic chart of the blood pressure of a patient who finally succumbed after 17 hours. In the present investigation further studies upon the effects of compression of the main pulmonary artery are reported. In addition a vary-

ing number of branches of the pulmonary artery were occluded and the effects upon the cardiorespiratory system noted.

Our experiments have been divided into two groups. In Group A the blood pressure, the saturation of arterial blood with oxygen and the respiratory minute volume and tidal air were determined before and during partial occlusion of the main pulmonary artery. In Group B similar determinations were made before and during complete occlusion of a varying number of the lobar branches of the main pulmonary artery.

METHOD.—Cats anesthetized by the intraperitoneal injection of sodium barbital (0.45 g. per Kg. of body weight) were used in all experiments. The carotid arterial pressure was recorded on a kymograph in the usual manner with a mercury manometer. A cannula was introduced into the trachea and connected through a T-tube with inspiratory and expiratory Krogh valves. The expired air was collected by connecting the expiratory valve with a Benedict-Roth recording spirometer. Three minute collections of expired air were made to compute the respiratory minute volume. Samples of arterial blood were withdrawn under oil from a femoral artery and the oxygen content and capacity determined.

In Group A the pulmonary artery was compressed by a clamp capable of very fine adjustments.¹⁰ The pulmonary artery was exposed in all but three experiments by removing a portion of the sternum, opening the pericardium, and making an airtight union between the opening in the pericardium and the opening in the wall of the chest.¹¹ With this preparation the pulmonary artery may be compressed and observations carried out in a normally breathing animal. In three experiments (Nos. 2, 3 and 4) the clamp was adjusted about the pulmonary artery through an intercostal incision and a small opening in the pericardium. The intercostal incision was then closed tightly around the shaft of the clamp. This preparation also permitted compression of the pulmonary artery in a normally breathing animal.

In Group B a varying number of lobar branches of the pulmonary artery were completely occluded by ligature. In all the experiments in this group the pericardium was sutured to the wall of the chest in the manner described by Drinker.¹¹ This gave access to the right and left main branches of the pulmonary artery in a naturally breathing animal. When the preparation was completed a record was made of the blood pressure, a sample of arterial blood was withdrawn for analysis and a record of the respiratory minute volume was made. A previously placed ligature was then tied about the right or left pulmonary artery completely occluding it. The observations were then repeated. When it was desired to shut off the blood supply to more than one lung, ligatures were tied about one or more lobar branches of the left pulmonary artery. The pericardium was then sutured to the wall of the chest. Occlusion of the right pulmonary artery then directed the entire output of the right heart through the unligated branches of the left pulmonary artery. Autopsies were always performed at the conclusion of the experiments to ensure that the vessels tied had remained completely occluded.

When it was desired to exclude the left middle lobe it was found to be technically simpler to ligate the pulmonary veins from this lobe instead of the artery. This produced the same fractional occlusion of the pulmonary circulatory bed that arterial occlusion would have accomplished. The known differences between the effects of vein and artery ligation in the lung were not considered significant to the problem at hand.

In order to estimate approximately how much of the total pulmonary vascular bed had been excluded from circulation by these ligations, the volume of pulmonary tissue represented by the right lung and the various lobes of the left lung was determined in ten normal cats. The trachea was clamped and the thoracic contents removed en masse. The lungs were then dissected free and the bronchi to the right lung and to the left upper, middle and lower lobes ligated. The right lung and the various left lobes were then separately immersed in water, the water displacement measured, and the percentage of the total lung volume calculated. The right lung varied between 54 and 66 per cent of the total lung volume, averaging 59.3 per cent. The left upper lobe varied between 7 and 9 per cent, averaging 7.4 per cent; the left upper and middle lobes together between 11 and 16 per cent, averaging 13.5 per cent; and the left lower lobe between 22 and 32 per cent, averaging 27.2 per cent. These averages were used in estimating the per cent of the pulmonary vascular bed excluded from the circulation by ligations of the branches of the pulmonary artery (Tables III and IV).

RESULTS.—Group A: Table I shows the systemic arterial blood pressure and the percentage saturation of arterial blood with oxygen before and dur-

TABLE I

BLOOD PRESSURE AND SATURATION OF ARTERIAL BLOOD WITH OXYGEN BEFORE AND DURING COMPRESSION OF THE MAIN PULMONARY ARTERY

Ex- peri- ment No.	Date	Weight of Cat Kg.	Before Partial Occlu- sion of the Pulmonary Artery		During Partial Occlu- sion of the Pulmonary Artery		
			Systemic Blood Pressure Mm. Hg.	Saturation of Arterial Blood with Oxygen Per Cent	Occlusion of Pulmonary Artery Per Cent	Systemic Blood Pressure Mm. Hg.	Saturation of Arterial Blood with Oxygen Per Cent
1	Oct. 15, 1930	2.64	125	90.2	undeter- mined	81	94.0
2	Oct. 22	2.57	103	89.8	undeter- mined	80	92.8
3	Oct. 27	3.00	140	94.0	undeter- mined	85	94.8
4	Oct. 29	2.84	83	94.8	undeter- mined	72	95.8
5	Oct. 31	2.85	126	91.7	88	90	93.6
6	Nov. 3	3.47	105	94.4	87	78	96.9
7	Nov. 5	3.55	78	92.0	61	62	92.8
8	Nov. 6	2.50	68	93.8	83	56	95.4

ing partial occlusion of the main pulmonary artery by the clamp. In Experiments 5 to 8, inclusive, the occlusion of the artery produced by the clamp was estimated in percentage of the original cross-sectional area.⁹ As previously shown, occlusion of approximately 60 per cent of the cross-sectional area of the artery produces a fall in systemic blood pressure. In all these experiments the pulmonary artery was compressed until a definite drop in blood pressure occurred. Without exception the saturation of arterial blood with oxygen increased slightly, from 0.8 to 3.8 per cent, when the pulmonary artery was compressed.

In Table II the changes in respiratory minute volume, respiratory rate and tidal air with partial occlusion of the pulmonary artery are shown. When the occlusion was sufficient to produce a drop in blood pressure, there was an increase in the respiratory minute volume. The respiratory rate showed a variable change and the tidal air was consistently increased during compression of the pulmonary artery.

TABLE II

RESPIRATORY MINUTE VOLUME, RESPIRATORY RATE AND TIDAL AIR BEFORE AND DURING COMPRESSION OF THE MAIN PULMONARY ARTERY

Experi- ment No.	Date	Weight of Cat	Oclu- sion of Pulmo- nary Artery	Systemic Blood Pressure	Respir- atory Minute Volume	Change in Respir- atory Minute Volume	Respir- atory Rate	Change in Respir- atory Rate	Tidal Air	Change in Tidal Air
		Kg.	Per Cent	Mm.Hg.	Cc.	Per Cent	Per Min.	Per Cent	Cc.	Per Cent
9	Oct. 21, 1930	2.8	0	95	995		50		19.9	
			+	76	1,068	+ 7	44	-12	24.3	+22
			+ +	63	1,140	+15	45	-10	25.3	+27
10	Feb. 24, 1931	3.18	0	113	860		28		30.7	
(a)			84	65	1,089	+27	30	+ 7	36.3	+18
(b)	Feb. 24	3.18	0	99	1,026		28		36.6	
			61	98	1,026	0	23	-18	44.6	+22
(c)	Feb. 24	3.18	0	98	819		19		43.1	
			77	75	1,285	+57	20	+ 5	64.2	+49

Group B: The changes in blood pressure and arterial oxygen saturation following ligation of branches of the pulmonary artery are shown in Table III. Up to 67 per cent occlusion of the pulmonary vascular bed there is no significant change in the blood pressure. In Experiment 18 with an occlusion of 73 per cent there was a definite rise in blood pressure. With 86 per cent occlusion, *i.e.*, with the pulmonary circulation confined to the left upper

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and middle lobes, there was a definite lowering of the blood pressure in Experiment 14, and a rise followed by a drop in Experiment 16.

TABLE III

BLOOD PRESSURE AND SATURATION OF ARTERIAL BLOOD WITH OXYGEN AFTER PARTIAL OCCLUSION OF THE PULMONARY VASCULAR BED

Ex- peri- ment No.	Date	Weight of Cat Kg.	Pulmonary Tissue Receiving Output of Right Heart	Occlusion of Pulmo- nary Vascular Bed Per Cent	Systemic Blood Pressure Mm. Hg.	Saturation of Arterial Blood with Oxygen Per Cent
11	Dec. 8, 1930		Both lungs	0	99	90.9
			Right lung	40.7	96	87.3
12	Dec. 10	2.72	Both lungs	0	86	
			Left lung	59.3	92	
13	Dec. 12	2.6	Both lungs	0	81	84.7
			Left lung	59.3	84	87.1
14	Dec. 13	2.58	Right lung and left upper and middle lobes	27.2	120	
			Left upper and middle lobes	86.5	95	
15	Dec. 19	3.04	Right lung and left lower and middle lobes	7.4	96	92.1
			Left lower and middle lobes	66.7	100	89.4
16	Jan. 5, 1931	5.11	Right lung and left upper and middle lobes	27.2	136	87.9
			Left upper and middle lobes	86.5	168-92	32.6
17	Feb. 10	3.81	Right lung and left lower lobe	13.5		92.0
			Left lower lobe	72.8		86.3
18	Feb. 12	4.15	Right lung and left lower lobe	13.5	89	
			Left lower lobe	72.8	123	
19	Feb. 18	5.05	Right lung and left upper and middle lobes	27.2		91.6
			Left upper and middle lobes	86.5		24.7

With one exception (No. 13), there was a definite drop in the arterial oxygen saturation following occlusion of 41 to 86 per cent of the pulmonary vascular bed. In Experiment 13 there was an abnormally low arterial oxygen saturation in the control period *before* ligating the right pulmonary artery. This was the only experiment in which an attempt was made to withdraw arterial blood from the left ventricle by direct puncture. The attempt was unsuccessful and immediately afterward an arterial sample with low oxygen saturation was obtained from a femoral artery. In two experiments (Nos. 16 and 19) there was a profound drop in the saturation of

arterial blood with oxygen following 86.5 per cent occlusion of the pulmonary vascular bed. In Experiment 16 the animal was killed by accidental inhalation of water three and one-half minutes after confining the pulmonary circulation to the left upper and middle lobes and two minutes after the blood sample for oxygen determination had been withdrawn from the femoral artery. In Experiment 19 the animal was revived by the inhalation of oxygen following which the arterial oxygen saturation rose from 24.7 to 68.5 per cent. In Experiment 14, with a similar occlusion of 86.5 per cent, the animal died six minutes after ligation of the right pulmonary artery. No samples of blood were withdrawn for analysis in this experiment.

The respiratory minute volume, respiratory rate and tidal air with varying degrees of occlusion of the pulmonary vascular tree are shown in Table IV. There was always an increase in respiratory minute volume; a variable change, generally an increase, in respiratory rate; and a consistent increase in tidal air.

TABLE IV

RESPIRATORY MINUTE VOLUME, RESPIRATORY RATE AND TIDAL AIR WITH PARTIAL OCCLUSION OF THE PULMONARY VASCULAR BED

Experi- ment No.	Date	Weight of Cat Kg.	Pulmonary Tissue Receiving Output of Right Heart	Occlu- sion of Pulmo- nary Vascular Bed Per Cent	Respir- atory Minute Volume Cc.	Change in Respir- atory Minute Volume Per Cent	Respir- atory Rate Per Min.	Change in Respir- atory Rate Per Cent	Tidal Air Cc.	Change in Tidal Air Per Cent
12	Dec. 10, 1930	2.72	Both lungs	0	387		15.5		25.0	
			Left lung	59.3	577	+49	18.5	+19	31.2	+20
13	Dec. 12	2.6	Both lungs	0	466		30.5		15.3	
			Left lung	59.3	487	+5	30.0	-2	16.2	+6
14	Dec. 13	2.58	Right lung and left upper and middle lobes	27.2	887		35.5		25.0	
			Left upper and middle lobes	86.5	1,333	+53	36.5	+3	36.5	+46
15	Dec. 19	3.04	Right lung and left lower and middle lobes	7.4	621		23.5		26.4	
			Left lower and middle lobes	66.7	987	+59	31.0	+32	31.8	+20
16	Jan. 5, 1931	5.11	Right lung and left upper and middle lobes	27.2	1,529		23.5		65.0	
			Left upper and middle lobes	86.5	3,448	+125	30.0	+28	114.9	+77
18	Feb. 12	4.15	Right lung and left lower lobe	13.5	446		17.5		25.5	
			Left lower lobe	72.8	833	+87	19.5	+11	42.7	+67

DISCUSSION.—The lowered blood pressure with varying degrees of occlusion of the pulmonary artery is shown in Table I. An occlusion of approximately 60 per cent produces a significant lowering of the systemic blood pressure. The lowered blood pressure is at least in part due to the diminished cardiac output resulting from constriction of the pulmonary artery.⁹ On the other hand, there is no lowering of the blood pressure with occlusion of up to 86 per cent of the peripheral pulmonary vascular bed, as can be seen in Table III. Indeed, in one instance (No. 18) there was a definite rise in pressure. The probable explanation for this difference lies in the fact that a small fraction of the pulmonary vascular bed can accommodate the entire

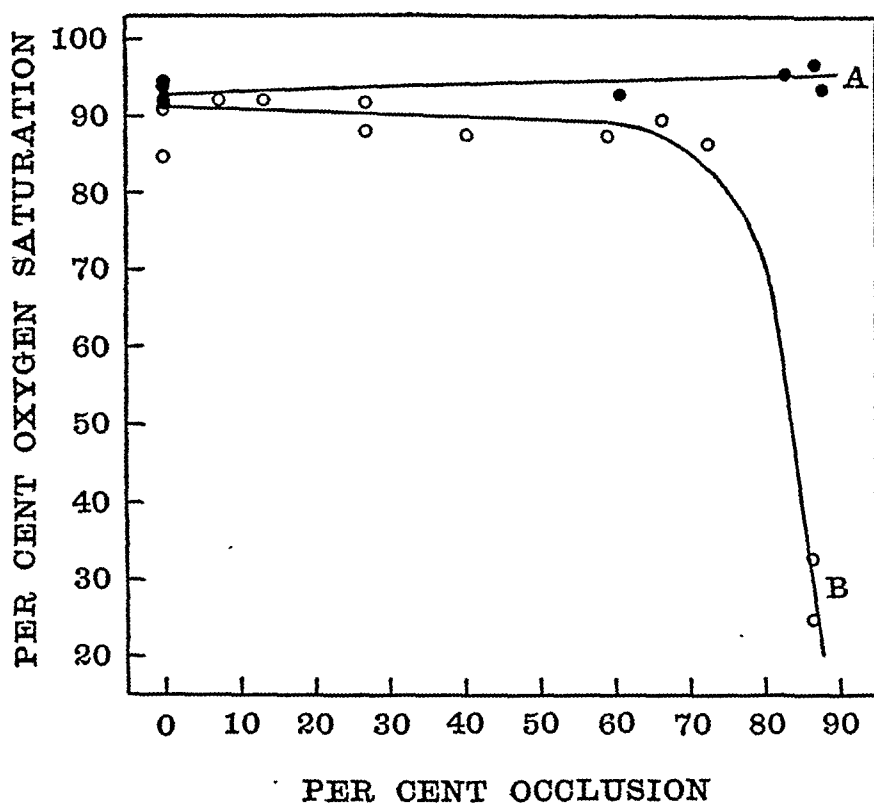


CHART 1.—Graphic illustration of the difference in arterial oxygen saturation with occlusion of the pulmonary artery (A) and with occlusion of its lobar branches (B). The solid dots and the straight line (A) represent the percentage saturation of arterial blood with oxygen before and during partial occlusion of the pulmonary artery. The circles and the curved line (B) represent the percentage saturation of arterial blood with oxygen before and during partial occlusion of the pulmonary vascular bed.

output of the right heart. There is already some evidence that an increased blood flow is associated with a lowering of resistance in the pulmonary vessels.¹²

The slight increase in the percentage saturation of arterial blood with oxygen observed with compression of the main pulmonary artery (Table I and Chart 1) may be due to a slower movement of blood throughout the whole pulmonary capillary tree, because of the diminished output of the right heart. A more complete saturation of the blood with oxygen would tend to result from the slower passage of blood through the pulmonary capillaries. On the other hand, when the output of the right heart is confined to the blood vessels of one lung, or a part of one lung, the opposite effect obtains

(Table III and Chart 1). A 40 to 75 per cent occlusion of the pulmonary vascular bed resulted, with one exception, in a slight but significant reduction in the saturation of arterial blood with oxygen. Eighty-five per cent occlusion produced marked lowering in the oxygen content, and proved fatal without the inhalation of oxygen in two instances. In the third instance the animal was accidentally killed a few minutes after the occlusion was effected. The explanation offered by Binger⁸ may well apply here. The pulmonary vessels are congested and the blood flow is rapid. This results in an impaired diffusion of oxygen into the blood and a consequent lowering of the per cent saturation.

No significant differences in the respiratory changes resulting from partial occlusion of the pulmonary artery and partial occlusion of the pulmonary vascular tree were observed in the few experiments performed. With compression of the pulmonary artery sufficient to cause a drop in blood pressure there was an increase in total pulmonary ventilation, a variable change in respiratory rate and a consistent increase in tidal air (Table II). That these changes are not due to a decrease in oxygen saturation of arterial blood is evident (Table I). They might be due to the reduction in cardiac output⁹ occasioning an accumulation of carbon dioxide or possibly a lack of oxygen in the respiratory center. A similar increase in total pulmonary ventilation and tidal air occurs with partial occlusion of the pulmonary vascular bed (Table IV). There is also generally an increase in the respiratory rate. These changes are due to the decreased oxygen saturation of arterial blood and can be prevented by oxygen inhalation.⁸ This was illustrated in Experiment 19 (not included in Table IV) in which a rapidly developing respiratory and circulatory failure following 86 per cent occlusion of the pulmonary vascular bed was overcome by administering oxygen. The percentage saturation of arterial blood which had fallen to 24.7 was raised to 68.5 per cent. Prior to the occlusion, the respiratory minute volume was 1,492 cc., the respiratory rate 28 per minute, and the tidal air 53.3 cc. After the occlusion and with the administration of oxygen, the figures were 1,264, 30 and 41.8 respectively.

SUMMARY.—Occlusion of more than 60 per cent of the main pulmonary artery results in a reduction of cardiac output, a fall in systemic blood pressure, an elevation of venous pressure, a slight increase in the saturation of arterial blood with oxygen, an increase in total pulmonary ventilation and tidal air and a variable change in respiratory rate.

With an occlusion of 40 to 73 per cent of the peripheral vascular bed of the lungs, the systemic blood pressure remains constant or is elevated, the saturation of arterial blood with oxygen is decreased and there is an increase in total pulmonary ventilation and tidal air with a variable change in the respiratory rate.

When 86 per cent of the pulmonary vascular bed is occluded, there is a fall in systemic blood pressure and a profound decrease in the saturation of

arterial blood with oxygen resulting in death. Inhalation of oxygen increases the oxygen saturation of the blood and maintains life.

These experimental findings aid in the interpretation of certain clinical observations in patients with pulmonary embolism.

CONCLUSIONS

These experimental observations point the way to a clearer understanding of the symptoms of pallor, cyanosis, air hunger, *etc.*, which have been observed in patients with massive pulmonary embolism. The "syncopale" type observed by Rochet would correspond to an experimental occlusion of the main pulmonary artery. The "asphyxique" type corresponds to the experimental occlusion of the larger branches of the pulmonary artery. From the experimental evidence the following presumptions seem justified. Where symptoms of pallor and lowered blood pressure predominate in a patient suffering with pulmonary embolism, the embolus produces the greatest degree of obstruction in the pulmonary artery at or above the point of bifurcation. Where cyanosis is a prominent feature and the lowering of the blood pressure is slight or absent, the embolus blocks at least one main branch of the pulmonary artery, and possibly some of the smaller branches of the other. More exact conclusions might be reached by determining the percentage saturation of arterial blood with oxygen. Finally, oxygen inhalations may be a life saving measure where there is marked diminution in the pulmonary vascular bed, and hence should certainly be given in all cases with the slightest evidence of cyanosis.

The respiratory changes occur in both types of obstruction and although perhaps more marked with occlusion of the peripheral vascular bed the difference is not great enough to be significant. The increased depth of respiration, however, remains an important diagnostic feature in all cases of massive pulmonary embolism. Elevation of the venous pressure regularly occurs with the obstruction of the main pulmonary artery.⁹ On two occasions the venous pressure was measured in the peripheral type of obstruction. In one instance there was an increase of 10 Mm. water pressure with 86 per cent occlusion, and in the other no change was observed with 73 per cent occlusion.

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PULMONARY EMBOLECTOMY

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No SUCCESSFUL case of operative intervention in massive pulmonary embolism has been reported in this country, and but few unsuccessful attempts are recorded.^{1, 2, 3, 4, 5} The European surgeons who have had the most experience with the Trendelenburg operation, some of them successful, have felt that the procedure should be more widely practiced and have urged that even the unsuccessful cases be reported in order that the diagnostic and technical difficulties may be clarified.^{6, 7, 8, 9} With this in mind, it seems appropriate to describe a recent unsuccessful embolectomy, particularly since this experience has demonstrated to us the feasibility of the procedure and has given us reason to hope that further efforts may prove successful.

CASE REPORT

A man, age 59, was convalescent following a suprapubic prostatectomy when, on the tenth postoperative day, he experienced a sudden attack of dyspnea with moderate cyanosis. This attack lasted only a few minutes and the patient was comfortable until 24 hours later when, while eating supper, a second more severe seizure occurred. The patient was seen at 4:55 P.M. two or three minutes after the onset of symptoms. He was sitting up in bed with a slightly cyanotic pallor and was gasping for breath. His pulse was very rapid and weak. He was rushed to the operating room thrashing about so wildly that it seemed he would throw himself out of bed. Just as he was being wheeled into the amphitheater, however, he became motionless, respirations ceased, and the heart sounds could not be heard at the apex. The chest was quickly shaved and the operation was begun without anesthesia. The Trendelenburg armamentarium, which is kept constantly in readiness, provided sterile gown, gloves, and instruments. The patient at this time, about eight minutes from the onset of symptoms, was clinically dead.

The second, third and fourth costal cartilages were resected through a straight incision along the left border of the sternum, and the outer third of the sternum was removed with large rongeurs. There was no bleeding. The pericardium was opened with some difficulty because of the enormously distended right ventricle bulging up beneath. The heart was motionless. The Trendelenburg sound was passed behind the aorta and pulmonary artery, the rubber tourniquet was drawn into place and the pulmonary artery was opened just distal to the valve by a longitudinal incision 2 cm. in length. A firm clot 30 cm. long and 2 cm. wide at the center, tapering at either end, was removed from the right branch. No clot was found in the left branch. The incision in the artery was closed with the Trendelenburg clip and the vessels allowed to drop back into place. About five minutes had elapsed since the cessation of respiration. The heart was massaged manually for a few moments without result. Five cc. of adrenalin were injected into the heart and further massage resulted in a faint irregular pulsation which gradually increased in amplitude, becoming a regular full beat. During this period the heart was irrigated with warm saline solution and artificial respiration was carried on through a metal airway. A small rent which had been torn in the pleura was plugged with moist cotton. After about ten minutes, spontaneous respiration was resumed which became regular and deep. The patient's color returned to normal, he began to perspire

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and there were slight movements of the extremities. He remained in this favorable condition for some 30 minutes, when, just as preparations were being made to suture the artery, the clip slipped off, apparently due to the vigorous motion of the heart. It was replaced with some difficulty in the bloody field by reapplying traction on the tourniquet. On release the heart dilated rapidly and stopped beating, assuming the appearance it had shown on opening the pericardium. Inspection showed that the clip had been placed so as to almost occlude the artery. This was readjusted but measures to restore the heart action were now without avail. Permission for autopsy was not obtained.

The Trendelenburg operation has been undertaken at the Peter Bent Brigham Hospital four times during the past three years. During this period the diagnosis of massive pulmonary embolism has been made in 12 patients, all of whom died. In several of these cases an autopsy was not made, but the clinical picture was quite typical. In three of the four operated cases the diagnosis was confirmed at operation. In the fourth case no clot was recovered so the diagnosis may have been in error, but as no autopsy was made, this could not be established. In six cases death had occurred by the time the House Officer had reached the bedside. The patient described above died eight minutes after the onset of symptoms, and was revived temporarily by embolectomy. Two patients survived the embolism by 15 minutes but operation was not attempted. Two patients survived for 20 minutes. Both of these were subjected to embolectomy, by Dr. R. Zollinger and by Dr. E. C. Cutler, the first just after death, and the second just before death. In neither of them could the heart action be restored after extraction of the clots. In the second case the aorta was opened by mistake and had to be sutured before proceeding with the embolectomy.

In the fourth case, operated upon by Dr. E. C. Cutler, the pulmonary artery was explored just after death but no clot could be found. Although autopsy was refused, it seems possible that there was a friable embolus which had been scattered into the smaller branches of the pulmonary artery out of reach of the forceps or suction. The clinical circumstances were typical of pulmonary embolism.

CASE REPORT

A young robust woman of 34 had, 18 months previously, suffered a very definite though non-fatal pulmonary embolism following the excision of postphlebitic ulcers of the legs. The ulcers had recurred and a second excision and grafting had been performed. Three weeks later a superficial phlebitis of the left thigh appeared and, at about the same time, a pleuritic pain in the left chest. Four days later there was a sudden attack of severe dyspnea and cyanosis followed shortly by pallor and loss of consciousness. She was seen within a few minutes by the House Officer who noted that the neck veins were distended. Five minutes later, when the operation was begun, respiration and heart action had ceased.

The difficulty of avoiding injury to the pleura has been stressed by all of the surgeons who have attempted embolectomy. The operative approach described by Meyer,¹⁰ minimizes this hazard. An opening in the pleura, however, does not necessarily mean failure for a small defect can be effectively controlled with moist cotton. Nyström⁶ injured the pleura in six cases,

including his three operative recoveries, out of a total of ten reported operations. The pleura was likewise injured in the patients, reported by Westerbörn⁷ and by Petterson,⁹ who survived operation by 16 and 3 hours, respectively. The possibility of mistaking the aorta for the pulmonary artery must be kept in mind, especially in the exceptional instance where the right ventricle and pulmonary artery are not dilated. This error was made in the first case of Nyström's series and was likewise made in one of our cases. Both of these errors could have been prevented by sufficient practice on the cadaver. A third technical error was demonstrated in the case described in this paper. The clip was allowed to remain in place long enough to be gradually worked loose by the vigorous heart beat. It would seem wiser to have proceeded with the arterial suture as soon as the heart action had been restored.

Much has been written about the clinical diagnosis of massive pulmonary embolism. We have been impressed by the fact that the clinical diagnosis is only rarely mistaken. It must be admitted, however, that errors in diagnosis may occur and this fact added to the consideration that an occasional case of massive pulmonary embolism recovers spontaneously leads one to the conclusion that operative intervention should be undertaken only when the patient is moribund.

There has been some difference of opinion as to whether the operation should be undertaken only by senior surgeons or whether it should be entrusted to a member of the resident hospital staff. In order to determine the operative possibilities in this regard a survey was made of all the proven cases of death from massive pulmonary embolism in the Peter Bent Brigham Hospital during the past 23 years. There were 92 cases in all. In 33 operation would have been out of the question because the patient was found dead or else died shortly after the initial symptoms (Table I).

TABLE I

Found dead in bed.....	5 cases
Died immediately during attack.....	9 cases
Lived five minutes or less after onset.....	19 cases

In 36 cases the patient survived for ten minutes to one hour (Table II).

TABLE II

Survived after onset for 10 minutes.....	8 cases
Survived after onset for 15 minutes.....	8 cases
Survived after onset for 20 minutes.....	11 cases
Survived after onset for 30 minutes.....	3 cases
Survived after onset for 45 minutes.....	5 cases
Survived after onset for 60 minutes.....	1 case

In this group it is reasonable to assume that successful surgical intervention would have to have been undertaken by someone in the hospital at the time of the accident. In only 12 of these cases, however, did this occur between the hours of 9 A.M. and 5 P.M., when a senior surgeon would have been available.

In 15 cases there was a survival period of one to 12 hours (Table III).

TABLE III

Survived after onset for 1 hour and 15 minutes..	3 cases
Survived after onset for 1 hour and 30 minutes..	3 cases
Survived after onset for 2 hours.....	4 cases
Survived after onset for 4 hours.....	2 cases
Survived after onset for 8 hours.....	2 cases
Survived after onset for 12 hours.....	1 case

In the group which comprise Table III there would have been sufficient time to call the senior surgeon. In general, however, these patients are not in the most favorable condition for operation, as the heart is likely to become too exhausted to be revived, or, as Churchill⁴ has pointed out, a state of peripheral circulatory collapse may develop which probably would make recovery impossible. Moreover, secondary thromboses may occur within the pulmonary arborization.

In the final group of eight cases, the survival period was from one to five days. Here the likelihood of extensive thrombosis is so great that successful surgical intervention would seem out of the question.

CONCLUSIONS

The operation of pulmonary embolectomy must be undertaken by a member of the resident staff, if the procedure is to be ventured in the majority of the favorable cases.

It is believed that the clinical picture in these fatal cases is sufficiently clear cut that mistakes in diagnosis will be very few and that where the diagnosis is in error little harm can accrue since the patients are obviously moribund.

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ACUTE PERFORATION OF GASTROJEJUNAL ULCER*

REPORT OF TEN NEW CASES AND A REVIEW OF NINETY-THREE
COLLECTED CASES

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THE term gastrojejunal ulcer is used in this paper to include all secondary ulcers situated at or adjacent to anastomoses between the stomach and jejunum irrespective of their gastric, marginal or jejunal location. The qualifying term acute perforation sometimes is used loosely in the literature to include subacute perforation, gastrojejunocolic fistula or fistula through the abdominal wall. It is restricted here to the use ordinarily made of it in this country with reference to perforation of peptic ulcer which corresponds to the German expression acute perforation into the free peritoneal cavity. Whereas ulcers which occur in the region of gastrojejunal anastomoses seem to possess the etiologic and pathologic features of primary peptic ulcer, they are to be distinguished from the latter by virtue of their occurrence in a small but definite proportion of cases as a sequel to surgical anastomosis. Synonyms include anastomotic ulcer, marginal ulcer, secondary jejunal ulcer, *ulcus pepticum jejuni* and peptic jejunal ulcer. Gastrojejunal ulcer is to be differentiated also from the rarely occurring primary jejunal ulcer.

Eighteen years after Woelfler⁹⁹ (1881) performed the first successful gastrojejunostomy, Braun⁶ (1899) reported the first case of gastrojejunal ulcer. A point of interest here is that the first case of gastrojejunal ulcer to be reported was one in which acute perforation took place. Goepel²⁵ reported the first successful suture of acute perforation of gastrojejunal ulcer in 1902. In one of the earliest comprehensive papers on the subject, Pater-son,⁶⁵ in 1909, originated the term gastrojejunal ulcer. At that time, ten years after the first case was reported, he stated that there were 52 authenticated cases of gastrojejunal ulcer on record.

ETIOLOGY.—*Incidence*.—Because it is known that many of the observed cases have not been reported, it is readily admitted by those who have written on this topic, that it is not possible to determine the frequency of occurrence of gastrojejunal ulcer. There are numerous casual references in the literature to cases of acute perforation of gastrojejunal ulcer. It is doubly difficult, therefore, if not impossible, to determine the incidence of this complication of gastrojejunal ulcer. Published estimates of the occurrence of gastrojejunal ulcer vary from 1.4 (Walton⁹⁵) to 34 (Lewisohn⁵⁰) per cent. In 129 cases of gastrojejunal ulcer collected by Lieblein,⁵³ there were 30 cases of acute perforation, or an incidence of 23 per cent. If we accept Sokolov's⁸² and Lahey and Jordan's⁴⁸ estimates that 1,000 cases of

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gastrojejunal ulcer have been reported in the world literature, our search of the literature, which yielded 93 more or less complete case reports, would indicate an incidence of acute perforation in gastrojejunal ulcer of less than 1 per cent. Singer and Meyer⁸¹ point out that there is a relatively large group of unrecognized cases of free perforation which, if added to the known cases, would increase the percentage of incidence materially.

Contributory Etiologic Factors.—Until the problem of the etiology of primary peptic ulcer is solved, it is not likely that the cause of secondary gastrojejunal ulcer will be found. Some of the factors contributory to the production of gastrojejunal ulcer, which seem to have a bearing on acute perforation, will be briefly reviewed.

Despite our lack of knowledge regarding the direct or ultimate cause of gastrojejunal ulcer, two very important facts stand out. One is the peculiar susceptibility of the jejunum (the tissue susceptibility factor of Ochsner and his co-workers⁶³) to the influence of gastric juice. The other is the marked tendency of gastrojejunal ulcer to penetrate or perforate. The latter is attested to by the high frequency of subacute perforation of gastrojejunal ulcer and by the frequent occurrence of gastrojejunocolic fistula.

Many of the factors which seem to contribute to the incidence of uncomplicated gastrojejunal ulcer also appear to contribute to the frequency of complicating acute perforation of gastrojejunal ulcer. Factors on the part of the patient are constitutional predisposition (Ochsner, *et al.*⁶³), early age, male sex, high concentration of free hydrochloric acid, coexisting infection, and failure to follow postoperative medical management. Technical considerations which should be avoided by the surgeon are anterior gastrojejunostomy, artificial occlusion of the pylorus (von Eiselsberg pyloric exclusion), entero-anastomosis (Braun's or Roux's en Y), the use of the Murphy button and non-absorbable sutures. Gastrojejunal ulcer and in turn acute perforation has been reported but it is rare following resection of the stomach for malignant disease. It appears, therefore, that the same factors which contribute to the production of benign peptic ulcer seem to be operative in the formation of secondary ulcer.

The most common site of gastrojejunal ulcer is in the efferent limb of the jejunum.

PATHOLOGY.—The pathogenesis of acute perforation of gastrojejunal ulcer is apparently the same as that of acute perforation of primary peptic ulcer except that the jejunal mucosa is more susceptible than that of the stomach or duodenum to the proteolytic effects of gastric juice.

The essential gross and microscopic pathology is the same as that of primary peptic ulcer. The ulcer which perforates acutely usually is single but may be multiple. Except in gastrojejunocolic fistula, the tendency to heal is less common than in gastric or duodenal ulcer. There is a marked tendency toward recurrence manifest in some perforating gastrojejunal ulcers. An outstanding feature, and the one which chiefly concerns us here, is this tendency to penetrate and involve other tissues. Based on this characteristic,

gastrojejunal ulcers may be divided into three groups: (1) Non-penetrating ulcer which, while it may erode a blood vessel or obstruct the stoma of the anastomosis, does not extend beyond the wall of the stomach or jejunum. (2) Chronic penetrating ulcer, which may form an indurated mass involving the transverse mesocolon, the colon, the omentum or the anterior abdominal wall with or without abscess formation, or which may penetrate into the colon or through the abdominal wall with fistula formation. (3) Acute perforating ulcer, which allows the escape of gastric or jejunal content into the free peritoneal cavity. This tendency to acute perforation of ulcer is so marked in some patients that in one group acute perforation of gastric or duodenal ulcer is found to have preceded the performance of gastrojejunostomy whereas in a second group multiple successive perforations of gastrojejunal ulcer have taken place.

SYMPTOMS AND DIAGNOSIS.—Acute perforation of gastrojejunal ulcer may or may not be preceded by suggestive prodromal symptoms. When premonitory symptoms are present, they usually consist of recurring dyspepsia appearing from a few days to as long as 25 years after operation. The dyspepsia often is refractory to the usual alkali and dietary management. In gastrojejunal ulcer the pain is usually on the left of the midline and at or below the level of the umbilicus.

In acute perforation of gastrojejunal ulcer as in peptic ulcer the pain is usually sudden and severe. The subjective symptoms are so characteristic that in several recorded instances patients who have experienced previous perforations have made their own diagnosis. On examination, the greatest tenderness and rigidity may be in the left lower quadrant of the abdomen because the fluid which escapes through the perforation passes downward on the left of the vertebral column. The late symptoms and signs are those of perforative peritonitis.

In those patients in whom the evidence points to acute perforative peritonitis, the diagnosis of acute perforation of gastrojejunal ulcer is made chiefly on the history of the patient's having had a gastrojejunostomy performed. The most difficult but least important condition to be differentiated is perforation of recurrent gastric or duodenal ulcer, the primary and confirmatory signs of which, as recently shown by one of us (H.L.T.⁹¹), are characteristic in definite proportions of cases. In these latter conditions the recurrent symptoms more nearly simulate the original ulcer distress.

PROGNOSIS.—The prognosis in acute perforation of gastrojejunal ulcer, treated or untreated, is grave. Most of the untreated cases are fatal. Wright¹⁰² reported a mortality of 23 per cent in cases treated by simple suture with 10.4 per cent of good results and 31 per cent of which required further operation.

TREATMENT.—The prophylactic treatment of acute perforation of gastrojejunal ulcer begins with the treatment of gastric or duodenal ulcer, the principles of which are well known. Most students of gastrojejunal ulcer

are agreed that gastrojejunostomy should be restricted to cases in which pyloric obstruction is present and in which the acid values are low.

Except in late cases wherein progressive peritonitis has supervened, the active treatment of acute perforation of gastrojejunal ulcer is surgical. In late diffuse peritonitis the injudicious application of surgery may be not only harmful but fatal. With respect to treatment in early cases, it may be said that there are two schools of thought. The adherents to one school maintain that simple suture is safest and therefore sufficient for the primary operation and can be followed by medical management and by radical surgery later if required. The members of the second school believe that in selected cases curative measures are warranted. If the duodenal ulcer is healed and the pylorus is patent, the gastrojejunostomy may be taken down and normal continuity restored. If active peptic ulcer is present, pyloroplasty, gastroduodenostomy to the first or second portion of the duodenum or Pólya or Billroth partial gastrectomy may be employed.

It is hardly necessary to emphasize that adequate medical management, including elimination of infection, should be employed postoperatively when either primary or secondary ulcer is present.

REVIEW OF CASES REPORTED IN THE LITERATURE

Our review of the literature disclosed four interesting facts. The first is that relatively few exhaustive studies of this subject have been made. The most notable ones in English are those made by Paterson,⁶⁵ Massie,⁵⁶ and Singer and Meyer.⁸¹ The second interesting fact is that only 93 authenticated case reports of acute perforation of gastrojejunal ulcer could be found. Singer and Meyer⁸¹ state that the publication of Steden's⁸⁴ article in 1931 brought the total number of cases reported in the German literature to 20. In the general literature on gastrojejunal ulcer there are a number of casual references to cases of acute perforation into the free peritoneal cavity. Except from the standpoint of numbers these cases have little significance because they cannot in any way be considered as case reports useful for study. For example, Wright¹⁰² mentioned that 51 cases had been reported to him by the Fellows of the Association of Surgeons. Sokolov⁸² made a similar collection of 12 cases from among Russian surgeons. Hurst and Stewart³⁷ referred to eight cases and Graham and Lewis²⁶ to one case. The third interesting fact is that a number of cases reported as acute in reality have been subacute perforations or perforations into the colon or through the anterior abdominal wall. Singer and Meyer⁸¹ credit Fromme,²⁴ Florcken and Steden,²² McKelvey,⁵⁸ Recht⁷¹ and Urrutia⁹⁴ with a total of ten cases whereas we accept only four of them as cases of acute perforation into the free peritoneal cavity. Moreover, personal communications indicate that through error Lewisohn^{51, 52} mentioned one case and that Storey^{88, 89} included a case of subacute perforation and a case of primary perforation of the jejunum in his incidental report of five cases of acute perforation of gastrojejunal ulcer. The fourth point of interest is that there is a good

deal of confusion regarding certain cases. As an illustration, Mikulicz is credited as having reported five cases. As early as 1909, Paterson^{65, 66} classified three of these as doubtful and our study of the literature has disclosed that neither of the other two is a typical acute perforation of secondary ulceration at the gastrojejunal anastomosis. In 1899 and 1900, Kausch⁴⁴ reported from Mikulicz clinic a case of chronic perforating gastrojejunal ulcer which ultimately penetrated the anterior abdominal wall. In the *Handbook of Surgery* in 1903, Mikulicz and Kausch⁶⁰ made a parenthetical reference to a case wherein perforation of an acute gastrojejunal ulcer occurred in an infant soon after operation for hypertrophic stenosis of the pylorus. Freund,²³ in 1903, reported the same case from the standpoint of hypertrophic stenosis without reference to the gastrojejunal ulcer. Mikulicz,⁵⁹ also in 1903, reported briefly the same case to the American Surgical Association. Such instances of multiple reports of the same case have served to confuse rather than clarify the situation. In view of the foregoing facts and the fact that authenticated cases of acute perforation of gastrojejunal ulcer now number over 100, it seemed promising to combine these cases for a comprehensive study of a problem which is clinically distinct from that presented by primary peptic ulcer in any of its complicated forms or by gastrojejunal ulcer in any of the other forms in which it is seen to exist.

This study is made on a total of 103 cases, 93 of which were collected from the original case reports in the literature. It is our privilege to add ten new cases which are reported here for the first time. The latter group is composed of five cases of our own and five which were generously contributed to this study. For two of the latter we are indebted to Hinton³⁴ and for three to Storey⁸⁹ (Table VI).

AGE AND SEX.—Among the 92 cases in which the age was recorded there were cases in every decade of life from the first through the seventh. The single case in the first decade was in a child of five months. In the seventh decade there were two cases. Thirty-six per cent of the cases occurred in the fourth decade and 49 per cent in the third and fifth decades combined. Among the 99 cases in which the sex was recorded, 90 per cent occurred in males. Acute perforation of peptic ulcer therefore is predominantly a disease of the male sex and of the ages from 21 to 50.

PRIMARY PATHOLOGY.—The primary pathologic condition for which gastrojejunostomy was performed was recorded in 89 cases (Table I). Duodenal ulcer was present in 43 per cent, gastric ulcer in 30 per cent. Pyloric stenosis was recorded as the primary pathology in 20 per cent of the cases. Carcinoma of the stomach, gastropexy, gastric erosions, congenital hypertrophic stenosis of the pylorus, gastric and duodenal perforations and "no pathology found," each were reported in one case. It is probable that peptic ulcer was present as the cause of stenosis in many of the cases in the pyloric stenosis group.

TABLE I
PRIMARY PATHOLOGY

	Number	Cases
		Per Cent
Duodenal ulcer.....	38	42.6
Gastric ulcer.....	27	30.3
Pyloric stenosis.....	18	20.2
Carcinoma of stomach.....	1	1.1
Gastropsis.....	1	1.1
Gastric erosions.....	1	1.1
Congenital hypertrophic stenosis of pylorus.....	1	1.1
Gastric and duodenal perforations.....	1	1.1
No pathology found.....	1	1.1
Totals.....	89	99.7

COMPLICATIONS OF PRIMARY PATHOLOGY

	Number	Cases
		Per Cent
Acute perforation of peptic ulcer.....	24	27
Peptic ulcer with obstruction.....	20	22
Peptic ulcer with hemorrhage.....	11	12
Peptic ulcer with chronic perforation of pancreas....	2	2
Totals.....	57	63

TABLE I—Showing the uncomplicated and complicated primary pathologic conditions for which gastrojejunostomy was performed, to be followed later by acute perforation of a gastrojejunal ulcer. Peptic (gastric and duodenal) ulcer constituted the primary pathology in 72.9 per cent of cases. Acute perforation was the most common complication of peptic ulcer to be followed by acute perforation of gastrojejunal ulcer.

One of the four common complications of peptic ulcer was present in 63 per cent of the 89 cases in which primary pathology was recorded (Table I). Acute perforation of peptic ulcer was present in 27 per cent, peptic ulcer with obstruction in 22 per cent, hemorrhage in 12 per cent, and chronic perforation into the pancreas in 2 per cent of cases. It should be noted that the most common complication of primary peptic ulcer was acute perforation. Obstruction (exclusive of pyloric stenosis) was the next most common complication.

ORIGINAL OPERATION.—The form of the original operation was recorded in all of the 103 cases (Table II). Among these gastrojejunostomy was used in 92 cases, the posterior form in 45 and the anterior in 40 cases. Pyloric resection was utilized in 11 cases with the Billroth II and Pólya types each having been applied in four instances. Operative procedures used in combination with the above in 24 cases were entero-anastomoses, which were used in 16 cases, and pyloric exclusion utilized in five cases,

GASTROJEJUNAL ULCER

excision of ulcer and the Roux en Y operation which were used in one and two cases respectively. In making the anastomoses non-absorbable sutures were employed in eight and the Murphy button in four cases.

TABLE II
ORIGINAL OPERATION

	Cases
Gastrojejunostomy	
Posterior.....	45
Anterior.....	40
Type not stated.....	7
Total.....	92
Pyloric resection	
Billroth II.....	4
Pólya.....	4
Hofmeister.....	1
Type not stated.....	2
Total.....	11
Combinations with the above	
Entero-anastomosis.....	16
Pyloric exclusion.....	5
Roux en Y.....	2
Excision of ulcer.....	1
Total.....	24
Method of making anastomosis	
Non-absorbable suture.....	8
Murphy button.....	4

TABLE II. Showing the types of original operation which were followed by gastrojejunol ulcer complicated by acute perforation. Gastrojejunostomy was employed in 92 cases and pyloric resection in 11 cases. Other operative procedures combined with these were used in 24 cases. In making the anastomoses non-absorbable sutures were used in eight cases and the Murphy button in four cases.

Interval between Gastrojejunostomy and Acute Perforation.—The intervals between the performance of gastrojejunostomy and the occurrence of acute perforation of gastrojejunol ulcer were recorded in 101 cases. The shortest interval during which acute perforation occurred was five days and the longest 18 years. In 13 cases (13 per cent) perforation occurred within three months after operation. In 59 cases (58 per cent) it occurred within two years and in 85 cases (84 per cent) within five years. In only 16 cases (16 per cent) did perforation occur as late as from five to 18 years.

Pathology of Acute Perforation of Gastrojejunal Ulcer.—In the material collected for this study there are 120 acute perforations recorded in the 103 cases. Numerically, therefore, the perforations fall into two groups, one group representing multiple and the other single perforations.

Multiple Perforations.—The multiple perforations, likewise, fall into two groups. One subgroup consists of multiple simultaneous perforations and the other of multiple successive perforations (Table III). In three cases multiple (two) perforations were found to exist simultaneously at operation or autopsy. In one case the site of the perforations was not stated but in each of the other two cases the perforations were situated at the anastomosis and in the jejunum.

TABLE III
MULTIPLE ACUTE PERFORATIONS
Multiple (2) Simultaneous Perforations

Author	Cases	Site
Key.....	1	Not stated
Massie.....	1	Anastomosis and efferent limb
Charbonnel and Leuret.....	1	Anastomosis and jejunum
Total.....	3	

Multiple Successive Perforations

Author	Cases	Site		Total Acute Perforations
		Peptic Ulcer (Gastric or duodenal)	Gastrojejunal Ulcer	
Battle.....	1	1	3	4
Maylard.....	1	1	2	3
Henry.....	1	1	4	5
Steinberg.....	1	1	2	3
Riess.....	1	0	2	2
Robinson.....	1	0	2	2
Nixon and Lowry.....	1	0	3	3
Woodside.....	1	0	2	2
Dineen.....	1	0	2	2
Hinton and Church....	1	0	2	2
Schilling.....	1	0	2	2
Totals.....	11	4	26	30

TABLE III.—Tabulates the three cases of multiple simultaneous and 11 cases of multiple, successive, acute perforations of gastrojejunal ulcer.

In 11 cases multiple (from two to five) perforations were found to have occurred at different times. In four of these cases acute perforation of peptic (gastric or duodenal) ulcer preceded acute perforation of gastro-

jejunal ulcer. In this group of 11 cases acute perforation of gastrojejunal ulcer occurred twice in eight cases, three times in two cases, and four times in one case. There were four acute perforations of peptic ulcer which, combined with 26 acute perforations of gastrojejunal ulcer, comprise a total of 30 acute perforations of ulcer in the 11 patients. Acute perforation of peptic ulcer followed by single perforation of gastrojejunal ulcer has been discussed under primary pathology.

Single Perforations.—Single perforation of gastrojejunal ulcer occurred in 89 cases. The important pathologic features in these cases are included in the following section.

Site of Perforation.—In the 120 acute perforations of gastrojejunal ulcer in this study the site was recorded in 96 instances (Table IV). The perforation was in the stomach three times, at the anastomosis in 19 instances, and in the jejunum 74 times. Jeunal perforation occurred in the afferent limb ten times, opposite the anastomosis 19 times and in the efferent limb 45 times.

TABLE IV
SITE OF PERFORATION

	Number	Cases Per Cent
Stomach.....	3	3.1
At anastomosis.....	19	19.7
Jejunum		
Afferent limb.....	10	10.4
Opposite anastomosis.....	19	19.7
Efferent limb.....	45	46.8
Totals.....	96	99.7

ASSOCIATED PATHOLOGY

	Cases
Multiple ulcers.....	17
Hemorrhage.....	14
Gastrojejunocolic fistula.....	6
Gastric ulcer.....	2
Abscess.....	2
Obstruction	
At anastomosis.....	2
At pylorus.....	1
Total.....	44

TABLE IV.—Showing the site of perforation of and the pathology associated with acute perforation of gastrojejunal ulcer.

TABLE V

Primary Operation		TREATMENT		Secondary Operation Required	
Operation	No. of Cases	Deaths Cases	Per Cent Mortality	No of Cases	Operation
Not performed.....	22	2	90.9	2	Drainage of abscesses
Suture					{ Disconnection of gastrojejunostomy Gastroduodenostomy Pylorotomy Roux Pylorotomy Pólya Pyloric resection
Simple suture.....	51	9	17.6	4	
With excision of ulcer....	6	0	0.0		
With entero-anastomosis	5	0	0.0	1	
With jejunostomy.....	1	1	100.0		
Totals.....	63	10	15.8		
Disconnection of gastrojejunostomy.....	4	0	0.0	1	Posterior gastrojejunostomy
Gastrojejunostomy					
Type not stated.....	4	1	25.0		
Anterior.....	2	0	0.0	1	Disconnection of gastrojejunostomy
With entero-anastomosis	1	1	100.0		
Totals.....	7	2	28.5		
Pyloric resection					
Billroth II.....	4	0*	0.0		
Pólya.....	3	0	0.0		
Reichl-Roux.....	3	0	0.0		
Billroth I.....	1	0	0.0		
Mikulicz-Reichl.....	1	0	0.0		
Kronlein-Roux.....	1	0	0.0		
Hoffmeister.....	1	0	0.0		
Type not stated.....	3	1	33.3		
Totals.....	17	1	5.8		
Other operations					
Type not stated.....	2	?	†		
Appendectomy.....	1	1	100.00		
Resection of jejunum, anastomosis en Y and pyloric exclusion with ligature.....	1	0	0.0		
Totals.....	4	?	?		

* Death or recovery in 1 case not stated

† Death or recovery not stated

TABLE V.—Comparison of the different types of surgical treatment with results in 117 acute perforations of gastrojejunal ulcer. The mortality in the untreated cases reached the high point of 90.9 per cent whereas in simple disconnection of gastrojejunostomy the mortality was 0.0 per cent.

Associated Pathology.—Complicating pathology was associated with acute perforation of gastrojejunal ulcer in 44 cases. Multiple jejunal ulcers were present in 17 cases. In von Eiselsberg's case there were five jejunal ulcers in addition to a gastrojejunocolic fistula. Hemorrhage had complicated gastrojejunal ulcer in 14 cases. In six gastrojejunocolic fistulae were present. Gastric ulcer, intraperitoneal abscess and obstruction of the anastomotic stoma each was present in two cases and pyloric obstruction was present in one case.

Autopsy.—Autopsy was performed in 25 cases.

TREATMENT.—In the 22 cases in which primary operation was not performed there were 20 deaths representing a mortality of 90.9 per cent. In both of the patients who recovered secondary drainage of intraperitoneal abscesses was required. Simple suture of the perforation was carried out in 51 cases with nine deaths and a mortality of 17.6 per cent. Simple suture was combined with other procedures in 12 cases with one death. In 63 cases wherein simple suture of the perforation was carried out with or without other procedures the total mortality was 15.8 per cent. Disconnection of the gastrojejunostomy restoring the normal sequential relation of the stomach and intestine was utilized in four cases with no deaths. Gastrojejunostomy alone or combined with other procedures was used in seven cases with two deaths and a mortality of 28.5 per cent. Pyloric resection with various types of gastro-intestinal anastomosis was applied in 17 cases with only one death, making a mortality of 5.8 per cent. In the ten cases in which the interval between perforation and operation was mentioned, it was recorded as from immediately up to six hours in seven cases, from seven to 12 hours in two cases and on the next day in one case. In the case in which death resulted, the operation was performed 11 hours after perforation. In four cases other operations ranging from appendectomy to resection of the jejunum with a Y anastomosis and pyloric exclusion by ligature were used. As recovery or death was not recorded in two of these information concerning the mortality in this group is not complete (Table V).

MORTALITY.—Among the 117 acute perforations of gastrojejunal ulcer in this study the outcome (recovery or death) was not recorded in three instances. In the remaining 114 acute perforations there were 34 deaths, representing a gross mortality of 29.8 per cent.

CASE REPORTS

Case 1.—(Toland and Thompson). Male, aged 42. In 1921, onset of epigastric pain relieved by food and soda. Excision of duodenal ulcer, posterior gastrojejunostomy and cholecystostomy in 1924. Pain recurred six months later. In 1927, medical treatment for duodenal ulcer. In 1928, sudden severe pain in the epigastrium later shifting to the suprapubic region and referred to both shoulders. Physical findings consisted of retracted abdomen with generalized tenderness and board-like rigidity, dulness in the flanks but liver dulness was not obliterated. Diagnosis: Perforated duodenal or jejunal ulcer.

Operation three hours after onset of pain disclosed a large quantity of free fluid

in the pelvis and beneath the great omentum. A perforated ulcer 1.5 cm. in diameter was found on anterior wall of jejunum opposite the anastomosis. The scar of a healed ulcer was situated on the anterior wall of stomach 4 cm. proximal to the pylorus. Pylorus patent. Disconnection of gastrojejunostomy, closure of stomach and resection of a portion of ulcer bearing jejunum 12 cm. long with end-to-end anastomosis by suture. Closure of abdomen with drainage.

Pathologic Report.—Specimen of intestine 6 cm. long. Circular opening 14 Mm. in diameter with smooth mucosal edges apparently a gastrojejunostomy opening. Three cm. directly anterior to this opening is a second opening measuring 9×12 Mm. extending through the entire wall of the intestine with indurated and undermined mucosal edges typical of a peptic ulcer. Serosa moderately thickened about the opening and covered by a delicate layer of fibrin. No evidence of malignancy. Gross Diagnosis: Perforated jejunal ulcer. Recovery.

Three months after operation patient was readmitted to hospital for observation for recurrent epigastric pain. Fluoroscopic examination disclosed a dilated stomach and tendency for the barium to collect in the dilated duodenal loop. In 1929, patient was readmitted for persistent pain, after having vomited one quart of coffee ground material, followed by two copious tarry defecations. Red blood corpuscles, 1,480,000. Night retention of from 250 to 650 cc. Medical treatment for two months including transfusion of blood.

Second Operation.—Eighteen months after acute perforation of gastrojejunal ulcer: Many adhesions. Firm mass at pylorus. Head of pancreas hard and enlarged. Posterior no-loop gastrojejunostomy with sutures. General condition of patient too poor to risk resection of tumor at pylorus. Recovered. Readmitted to hospital two months post-operative because of persistence of pain in lower abdomen. Improved under medical treatment. When last examined in October, 1930, patient still complained of pain in the epigastrium. Medical treatment was advised.

Case 2.—(Toland and Thompson). Male, aged 36. In 1917, onset of periodic gnawing pain in the epigastrium appearing two to three hours after meals and relieved by vomiting. Diagnosis: Peptic ulcer. Medical treatment with relief for six months. In 1928, while eating, experienced severe abdominal pain.

Operation six hours after onset of pain disclosed a perforated duodenal ulcer. Sutured. In 1929, posterior gastrojejunostomy with partial relief of symptoms. In 1934, sudden attack of dizziness and vomiting of bright red blood, melena. Medical treatment. Three months later, one and one-half hours after a meal of soft food, patient experienced a sudden severe epigastric pain. Generalized abdominal rigidity was found on physical examination. Diagnosis: Perforated peptic ulcer.

Second operation three and one-half hours after onset of pain disclosed many adhesions but no evidence of peritonitis anterior to the great omentum. Entire region beneath the transverse colon filled with milky fluid. Multiple lesions in the omentum resembling fat necrosis. Perforation of anterior wall of jejunum directly below anastomosis 2 Mm. in diameter. Suture. Closure with drainage. Recovery. On follow-up five months postoperative, patient found to experience ulcer pain at intervals. Diagnosis: Marginal or jejunal ulcer.

Case 3.—(Toland and Thompson). Male, aged 65. In 1924, onset of pain following meals, relieved by soda. In 1929, vomiting of practically all food except fluids. Diagnosis: Peptic ulcer with obstruction. Posterior no-loop gastrojejunostomy for duodenal ulcer with obstruction. In 1934 after severe agonizing epigastric pain readmitted to the hospital where a diagnosis of perforated peptic ulcer was made. The patient stated that he had been free from symptoms until three weeks prior to this admission.

Operation disclosed perforated ulcer of afferent limb of jejunum. Mass in first portion of duodenum had disappeared. Suture and entero-anastomosis. Recovery.

Case 4.—(Toland and Thompson). Male, aged 34. In 1929, gnawing epigastric

pain after meals relieved by food, of three weeks' duration when patient experienced a sudden sharp stabbing epigastric pain. Examination disclosed moist cold skin and rigid abdomen. Diagnosis: Perforated peptic ulcer.

Operation disclosed ulcer anterior wall of pylorus with perforation 1 cm. in diameter. Suture and posterior gastrojejunostomy. Relief until 1934 when there was a recurrence of severe abdominal pain. Abdomen board-like and tender throughout. Diagnosis: Perforated peptic ulcer. *Operation*: Perforated ulcer at the margin of the gastrojejunostomy opening. Clear fluid in peritoneal cavity. Closure of perforation with sutures. Drainage of peritoneal cavity. On sixth day postoperative evisceration through a small opening in the incision. Secondary closure. Patient died on sixteenth day postoperative. Autopsy: Generalized peritonitis. Ulcer in greater curvature of stomach communicating with jejunum. Bilateral fibrinous pleuritis.

Case 5.—(Toland and Thompson). Male, aged 37. Gastrojejunostomy eight years ago for gastric ulcer. Recent examination for recurrence of symptoms at the Mayo Clinic resulted in a diagnosis of marginal ulcer and reactivation of duodenal ulcer. In September, 1935, patient experienced a sudden pain in the right upper quadrant of the abdomen. Examination disclosed a flat, rigid, tender anterior abdominal wall and obliteration of liver dulness. Diagnosis: Acute perforation of duodenal ulcer.

Operation disclosed an active duodenal ulcer, which was not ruptured, and an acute perforation of an ulcer in the efferent limb of the jejunum. Gentle manipulation of the jejunum caused a separation throughout half of the circumference of the anastomosis. Disconnection of gastrojejunostomy with suture of gastric and jejunal openings and restoration of normal anatomy. Recovery.

Case 6.—(Hinton). Male, aged 45. Posterior gastrojejunostomy for duodenal ulcer in 1920. In 1933, acute perforation of ulcer of efferent limb of jejunum. Simple suture. Recovery. Recurrence of pain. Further surgery advised.

Case 7.—(Hinton). Male, aged 55. Posterior gastrojejunostomy in 1929. On February 25, 1936, acute perforation of gastrojejunal ulcer situated in the efferent limb. Simple suture. Recovery.

Case 8.—(Storey). Male, aged 44. In 1924, posterior gastrojejunostomy for duodenal ulcer with obstruction. Relief for 11 months, when pain in the epigastrium associated with melena appeared. Gastric analysis disclosed hyperacidity and fluoroscopic examination with a barium meal revealed an accessory pocket near the stoma suggestive of ulcer. In 1925, operation disclosed a cavity filled with brown fluid situated between the jejunum and transverse mesocolon into which a perforation of the jejunum emptied. A piece of silk three inches long was removed from the neighborhood of the ulcer. The duodenum was contracted to the diameter of a little finger. Gastrojejunostomy disconnected, openings closed, anterior gastrojejunostomy performed. Recovery.

Case 9.—(Storey). Male, aged 52. In 1923, after having had epigastric pain for 12 months, anterior gastro-enterostomy and entero-anastomosis were performed. In 1928, sudden severe pain in the region of the umbilicus.

Operation disclosed adhesions between the omentum, stomach and abdominal wall and free fluid in the peritoneal cavity. A small perforation in the efferent limb of the jejunum was sutured. Recovery.

Case 10.—(Storey). Male, aged 47. In 1929, posterior gastrojejunostomy for duodenal ulcer with obstruction. In 1932, perforated bleeding jejunal ulcer opposite the stoma closed with sutures. Recovery.

Discussion.—In addition to the contribution of ten new cases of acute perforation of gastrojejunal ulcer to the literature, this study of 103 cases has emphasized a number of significant facts. They will be discussed under three broad headings; namely, etiology, pathology, and treatment.

Etiology.—This study reemphasizes that while acute perforation of gastro-

jejunal ulcer may occur at any period from infancy to old age, the fact that 85 per cent of cases were found to occur from the third through the fifth decade indicates that the condition is distinctly a disease of early and middle adult life. By a similarly large percentage of cases the condition also is seen to predominate in males.

An analysis of the data on the primary pathology has brought out two important facts. First, it confirms the prevailing impression that acute perforation of gastrojejunal ulcer occurs most frequently following peptic ulcer. What is more important, however, is that it illustrates how perforation of gastrojejunal ulcer may occur not only after malignancy of the stomach but also as an untoward sequela to gastrojejunostomy when performed in such benign conditions as gastric erosions, gastropsis or even in the absence of pathology. These points serve to emphasize further the inadvisability of application of this operation in functional conditions or when pathology is not demonstrable or is indefinite.

The second important fact is that pyloric stenosis was recorded as being the primary pathology in 18 cases. It will be noted that most of these cases were reported by early writers. One of us (H.L.T.⁴¹), in collaboration with Judd, has shown that while primary pyloric stenosis exists, its occurrence among adults is rare. While it is probable, therefore, that many if not all of the cases in this group were in reality pyloric or duodenal ulcer with secondary stenosis, the absence from the case reports of data which would enable us to distinguish the two forms made it necessary for us to recognize two groups. Had we combined the groups there would have been 38 cases or as high as 36.8 per cent of the entire series wherein acute perforation of gastrojejunal ulcer followed pyloric obstruction. This is of special interest in view of Wilkie's⁹⁶ recent statement that gastrojejunostomy should be performed only in cases of pyloric obstruction.

Analysis of the data on complications of the primary pathology is also significant. It is seen that complications were present in 63 per cent of the cases in which gastrojejunostomy was used. Acute perforation of peptic ulcer outnumbers peptic ulcer with obstruction by 5 per cent and becomes therefore the most common complication to be followed by acute perforation of gastrojejunal ulcer. By carrying the analysis to the point of distinguishing between the tendencies manifest by peptic ulcer we find that the liability to reactivation, as indicated by acute and chronic perforation and by erosion of blood vessels, outstrips the tendency to inactivity as shown by scarring and obstruction in a case ratio of 37 to 20.

The secondary nature and occurrence of gastrojejunal ulcer brings our consideration of the types of original operation under the heading of etiology. As gastrojejunostomy *per se* is an essential prerequisite to the formation of gastrojejunal ulcer, it is necessary for us to consider only the various types of this operation and the effects of the operations which were used in combination with it.

The comparative frequency of acute perforation of gastrojejunal ulcer

with respect to anterior or posterior gastrojejunostomy is striking. During the early history of gastrojejunal ulcer when anterior gastrojejunostomy was used more often than at present, the impression prevailed among students of this subject that perforating gastrojejunal ulcer was more commonly a sequela to anterior rather than to posterior gastrojejunostomy. Our figures reveal, however, that the condition is even more common after posterior gastrojejunostomy, so that the recorded cases now outnumber the others by 45 to 40.

The occurrence of acute perforation of gastrojejunal ulcer after pyloric resection is of interest from a physiologic standpoint. The impression is prevalent among physicians that pylorectomy reduces the secretion of hydrochloric acid. It has been shown experimentally by one of us (H.L.T⁹⁰) that this depends also on the amount of stomach mucosa resected and on the type and quantity of food consumed. Also of interest from a physiologic standpoint is the large number of acute perforations of gastrojejunal ulcer which occurred after entero-anastomosis. It would appear from these figures that any procedure which shunts the alkaline duodenal juices around the gastrojejunal stoma predisposes strongly to the formation of gastrojejunal ulcer. The use of mechanical devices such as the Murphy button and of non-absorbable sutures appear also to be predisposing factors.

Our findings that 58 per cent of acute perforations of gastrojejunal ulcer occur within two years are in agreement with the recent statements of Judd and Hoerner⁴⁰ in this regard.

Pathology.—The pathology of acute perforation of gastrojejunal ulcer especially with respect to multiple perforations is of interest. In view of the fact that multiple gastrojejunal ulcers are relatively common, it is not unusual that a few cases of multiple simultaneous perforations should be encountered.

From the clinical and therapeutic standpoint, one of the most important phases of this study is that of multiple successive acute perforations. The striking tendency of peptic and gastrojejunal ulcers to perforate is amply illustrated by acute perforation of peptic ulcer having preceded acute perforation of gastrojejunal ulcer in 24 cases and by the latter having occurred from two to four times in 11 cases. From this apparent total of 35 cases, four cases must be subtracted as common to both groups, leaving a real total of 31 cases which is 30 per cent of the entire series. When we note that gastrojejunocolic fistula was also associated with acute perforation in six cases, the point is even more striking. This evidence appears to be sufficiently convincing to justify the dictum that gastrojejunostomy should never be performed in unobstructed acute perforation of peptic ulcer. The tendency of peptic and gastrojejunal ulcers to perforation is so strong that in a significant proportion of cases it manifests itself over a period of weeks or years in multiple perforations.

The site of perforation having been found to be more frequent about the artificial stoma, and opposite or distal to it in the jejunum, supports the tissue susceptibility theory of Ochsner⁶³ and indicates that the corrosive

TABLE VI
SUMMARY OF REPORTED CASES OF GASTROJEJUNAL ULCER*

No.	Reported by Author	Year	Age in Years	Sex	Original Pathology	Original Operation	Interval	Pathology of Gastrojejunal Ulcer	Operation for Gastrojejunal Ulcer	Result	Remarks
1	Braun ⁶	1899	25	M.	Gastric ulcer, obstruction	Post. gastrojejunostomy	11 mos.	Jejunum, efferent	None	Death	
2	Hahn ³⁰	1899	—	—	Pyloric stenosis	Ant. gastrojejunostomy	1 yr.	Jejunum, afferent	None	Death	
3	Korte ¹⁶	1900	30	M.	Gastric ulcer, obstruction	Ant. gastrojejunostomy	3 yrs.	Jejunum, efferent	Appendectomy	Death	
4	Steinthal ³⁷	1900	44	M.	Chronic gastritis, hemorrhage	Post. gastrojejunostomy, Murphy button	10 da.	Jejunum, efferent	None	Death	
5	Goepel ²⁵	1902	—	M.	Pyloric stenosis	Ant. gastrojejunostomy	13 mos.	—	None	Death	See also Tiegel
6	Goepel ²⁵	1902	—	M.	Pyloric stenosis	Ant. gastrojejunostomy	4 mos.	—	Suture	Recovery	First case operated upon
7	Mikulicz ³³	1903	5 mos.	F.	Congenital hypertrophic stenosis, obstruction	Ant. gastrojejunostomy, entero-anastomosis	82 da.	Jejunum, afferent. Multiple ulcers. Hemorrhage	None	Death	
8	Brentano ⁷	1903	26	F.	Pyloric stenosis	Ant. gastrojejunostomy, entero-anastomosis	1 yr.	Anastomosis	New gastro-jejunostomy	Recovery	
9	Cackovic ¹¹	1903	30	M.	Pyloric stenosis, obstruction	Post. gastrojejunostomy	5 da.	Jejunum, efferent Multiple ulcers	None	Death	
10	Tiegel ³²	1904	34	M.	—	Ant. gastrojejunostomy	9 mos.	—	Suture	Recovery	
11	Dudgeon and Sargent ¹⁷	1905	30	M.	Gastric ulcer	—	22 mos.	—	Suture	Recovery	
12	Battle ²	1906	30	M.	Gastric ulcer, obstruction, hemorrhage	Ant. gastrojejunostomy, Murphy button	22 mos.	—	Suture	Recovery	
13	I [†]	1906	37	F.	Gastric ulcer, obstruction, acute perforation	Ant. gastrojejunostomy	13 mos.	Jejunum, efferent	Suture	Recovery	
	Battle ²	1906		F.	Gastric ulcer, obstruction, acute perforation	Ant. gastrojejunostomy	23 mos.	Anastomosis	Suture	Recovery	
	Battle ²	1918		F.	Gastric ulcer, obstruction, acute perforation	Ant. gastrojejunostomy	13 yrs.	Jejunum, efferent	Suture	Recovery	
14	Romanis ⁷⁵ Delaloye ⁴⁴	1906	41	M.	Duodenal ulcer, obstruction	Ant. gastrojejunostomy	6 yrs.	Anastomosis	None	Death	
15	Graser ²⁷	1906	—	F.	Gastric ulcer, obstruction	Post. gastrojejunostomy, Murphy button	4 yrs.	Jejunum, efferent, hemorrhage	None	Death	
16	Eiselsberg ²⁰	1906	—	M.	Gastric ulcer	Bilroth II	1 yr.	Stomach	None	Death	
17	Paterson ^{61, 65, 66}	1906	48	M.	Pyloric stenosis	Post. gastrojejunostomy	2 yrs.	Jejunum, efferent	None	Death	
18	Paterson ^{61, 65, 66}	1906	51	M.	Pyloric stenosis	Ant. gastrojejunostomy	2½ yrs.	Jejunum, opposite anastomosis	None	Death	
19	Key ⁴⁸	1907	45	F.	Gastric ulcer, obstruction, hemorrhage, perforation into pancreas	Ant. gastrojejunostomy Y	7 yrs.	Anastomosis	Excision of ulcer, enlargement of anastomosis, suture	Recovery	
20	Key ⁴⁵	1907	25	F.	Carcinoma stomach	Bilroth II	10 da.	Multiple ulcers, 2 simultaneous perforations	None	Death	

* In the compilation of the data in this table of collected cases the original case report was consulted in every instance.
† The Roman numeral indicates the number of each perforation as it occurred in cases in which multiple successive perforations took place.

GASTROJEJUNAL ULCER

21	Edington ¹³	1907	46	M.	Duodenal ulcer, obstruction	Ant. gastrojejunostomy	7 yrs.	Jejunum, efferent	Suture	Death
22	Hamann ²¹	1907	48	M.	Gastric erosions	Ant. gastrojejunostomy, Murphy button, Entero-anastomosis	26 da.	Jejunum, efferent	None	Death
23	Jainus ³	1907	—	M.	—	Post. gastrojejunostomy	11 mos.	Jejunum, opposite anastomosis	None	Death
24	Jensen ³⁹	1908	54	M.	Hemorrhage	Post. gastrojejunostomy	13 mos.	Jejunum, efferent	None	Death
25	Lion and Moreau ¹³	1900	43	M.	Pyloric stenosis	Post. gastrojejunostomy	8 yrs.	Jejunum, efferent, hemorrhage, jejuno-colic fistula	None	Death
26	Eiselsberg ²¹	1910	40	M.	Gastric ulcer	Post. gastrojejunostomy	2 mos.	Jejunum, opposite anastomosis, multiple (5) ulcers, jejuno-colic fistula	None	Death
27	I Maylard ³⁷	1910	51	F.	Gastric ulcer, acute perforation	Ant. gastrojejunostomy	8 mos.	Jejunum, efferent	Suture	Recovery
28	Maylard ³⁷	1910	51	F.	Gastric ulcer, acute perforation	Ant. gastrojejunostomy	3 yrs.	Jejunum, efferent	Suture	Recovery
29	Petren ⁶⁷	1910	39	M.	Gastric ulcer, obstruction, acute perforation	Post. gastrojejunostomy, entero-anastomosis	9 mos.	Anastomosis	Suture	Recovery
30	Petren ⁶³	1911	37	M.	Gastric ulcer, obstruction, acute perforation	Post. gastrojejunostomy	5 da.	Jejunum, afferent, multiple ulcers	Excision of ulcer, suture	Recovery
31	Hiltzro ³⁶	1911	18	M.	Gastric ulcer, obstruction, hemorrhage	Ant. gastrojejunostomy, Roux Y	7 yrs.	Jejunum, efferent	None	Death
32	Moynihan ⁶¹	1911	26	M.	Gastric ulcer, obstruction, hemorrhage	Ant. gastrojejunostomy	7 da.	Jejunum, opposite anastomosis	Suture	Recovery
33	Rowlands ^{70, 77}	1912	29	M.	Pyloric stenosis	—	5 yrs.	Jejunum, efferent	Suture	Death
34	Lindner ⁵¹	1912	50	F.	—	—	—	—	—	Recovery
35	Lindner ⁵¹	1912	—	M.	—	—	—	—	—	Recovery
36	Hartmann ³²	1913	41	M.	Pyloric stenosis	—	—	—	—	Death
37	Schmilinsky ⁷⁹	1918	—	—	Duodenal ulcer	Post. gastrojejunostomy, pyloric exclusion	6 yrs.	Anastomosis	Secondary operation: Disconnection	Death
38	Schmilinsky ⁷⁹	1918	—	—	Duodenal ulcer	Post. gastrojejunostomy, pyloric exclusion	6 yrs.	Anastomosis	Gastrojejunostomy	Recovery
39	Haberer ^{23, 29}	1918	40	M.	Duodenal ulcer	Post. gastrojejunostomy, pyloric exclusion	22 mos.	—	Died 2 days post-operative of acute perforation at first gastrojejunostomy	Recovery
40	Wright ¹⁰¹	1919	39	M.	Duodenal ulcer, obstruction	Ant. gastrojejunostomy	16 mos.	Jejunum, efferent	Suture	Recovery
							58 da.	—	Suture	Recovery
							19 mos.	Multiple ulcers, (4) colic fistula	Suture	Death
							—	Jejunum, efferent	Suture	Death
							—	—	Suture	Recovery

COLLECTED CASES—Continued

No.	Reported by Author	Year	Age in Years	Sex	Original Pathology	Original Operation	Interval	Pathology of Gastrojejunal Ulcer	Operation for Gastrojejunal Ulcer	Result	Remarks
41	Roberts ⁷³	1920	34	M.	Pyloric stenosis, acute perforation	Post. gastrojejunostomy	2½ mos.	Jejunum, afferent	Suture	Recovery	
42	Polya ⁴⁹	1920	36	M.	Duodenal ulcer	Post. gastrojejunostomy, pyloric exclusion	10 mos.	Jejunum, opposite anastomosis, multiple (4) ulcers	Suture	Death	
43	I Henry ⁷³ II Henry ⁷³ III Henry ⁷³ IV Henry ⁷³	1921	36	M.	Gastric ulcer, acute perforation	Ant. gastrojejunostomy	5 mos.	Jejunum, opposite anastomosis	Suture	Recovery	
		1921	—	M.	Gastric ulcer, acute perforation	Ant. gastrojejunostomy	2½ yrs.	Jejunum, efferent	Suture	Recovery	
		1921	—	M.	Gastric ulcer, acute perforation	Ant. gastrojejunostomy	4½ yrs.	—	Suture	Recovery	
		1921	—	M.	Gastric ulcer, acute perforation	Ant. gastrojejunostomy	6 yrs.	Anastomosis	Excision of ulcer, suture	Recovery	
44	Henry ⁷³ Urrutia ⁷⁴	1921	35	M.	Duodenal ulcer, acute	Post. gastrojejunostomy	14 mos.	Jejunum, efferent	Suture	Recovery	Secondary operation: Roux resection
45	Haberer ⁷⁵	1922	34	—	Gastric ulcer	Post. gastrojejunostomy	4 yrs.	—	Suture, jejunostomy	Death	
46	Brutt ⁷	1922	18	M.	Pyloric stenosis	Ant. gastrojejunostomy	3 yrs.	—	New gastro- jejunostomy	Recovery	
47	Brutt ⁷	1922	40	M.	Pyloric stenosis	Ant. gastrojejunostomy	6 yrs.	Jejunum, efferent, hemorrhage	Suture	Death	
48	McKelvey ⁵⁵	1922	44	M.	Gastric ulcer	Ant. gastrojejunostomy	18 yrs.	Anastomosis	Disconnection	Recovery	Secondary operation: Disconnected
49	Massie ⁵⁶	1924	28	M.	Duodenal ulcer	Ant. gastrojejunostomy	16 mos.	Multiple simulta- neous perforations (2): Anastomosis, jejunum, afferent	Suture	Recovery	
50	Bundschuh ⁸	1924	49	M.	Gastric ulcer	Ant. gastrojejunostomy, entero-anastomosis	14 yrs.	Jejunum, efferent, multiple ulcers (2): Acute per- foration, Je- junocolic fistula	Pyloric resection, Mikulicz- Reichel anastomosis	Recovery	
51	I Steinberg ⁵⁵ II Steinberg ⁵⁸	1924	36	M.	Duodenal ulcer, acute perforation	Post. gastrojejunostomy	—	Jejunum, efferent, multiple ulcers	Suture	Recovery	
		1936	—	M.	—	—	—	—	Suture	Recovery	
52	Schwarz ⁸⁰	1925	—	M.	Gastric ulcer	Ant. gastrojejunostomy	3 yrs.	Jejunum, opposite anastomosis	None	Death	
53	Schwarz ⁸⁰	1925	39	M.	Gastric ulcer	Ant. gastrojejunostomy	1 yr.	Anastomosis, multiple ulcers	Pyloric resection, Reichel-Roux anastomosis	Recovery	
54	Schwarz ⁸⁰	1925	33	F.	Duodenal ulcer	Ant. gastrojejunostomy	1½ yrs.	Jejunum, efferent	Reichel-Roux anastomosis	Recovery	
55	I Riess ⁷²	1925	27	M.	Gastric ulcer, perforation into pancreas	Ant. gastrojejunostomy	86 da.	Jejunum, opposite anastomosis	Excision of ulcer, suture	Recovery	

GASTROJEJUNAL ULCER

II
Reiss72

56

Charbonnel and Leuret¹²

1925 — M.

1925 60

M. Gastric ulcer, obstruction

Post. gastrojejunostomy

9 mos.

Jejunum, afferent, Pyloric resection, multiple ulcers Billroth II, anastomosis Suture Recovery

57 Zeno¹⁰³

1926 23

M. Duodenal ulcer, acute perforation

Post. gastrojejunostomy

3 yrs.

Multiple (2) simultaneous perforations: Anastomosis, jejunum, efferent Suture Death

58 Ashcroft¹¹

1926 38

M. Duodenal ulcer, acute perforation

Post. gastrojejunostomy

5 mos.

Anastomosis, Ant. gastro-jejunosomy Recovery

60 Winkelbauer⁹³

1926 37

M. Duodenal ulcer

Post. gastrojejunostomy

19 mos.

Jejunum, efferent Suture, entero-anastomosis Recovery

61 Kunz¹⁷

1926 22

M. Duodenal ulcer, hemorrhage, acute perforation

Post. gastrojejunostomy

9 mos.

Jejunum, efferent Suture, entero-anastomosis Recovery

62 Kunz¹⁷

1926 34

M. Pyloric stenosis

Ant. gastrojejunostomy

10 mos.

Jejunum, opposite Pyloric resection, anastomosis Pólya anastomosis Recovery

63 Delor y Castro¹⁵

1926 31

M. No ulcer found

Ant. gastrojejunostomy, entero-anastomosis

16 mos.

Pólya anastomosis Recovery

8845

64 Spath⁸³

1926 49

M. Duodenal ulcer

Ant. gastrojejunostomy, entero-anastomosis

16 mos.

Pyloric resection Recovery

65 Jura⁴²

1927 33

M. Duodenal ulcer

Gastrojejunostomy

2 yrs.

Anastomosis Pyloric resection, Reichel-Roux anastomosis Recovery

66

Brut¹⁰

1927 37

M. Duodenal ulcer, hemorrhage

Ant. gastrojejunostomy, entero-anastomosis

7 mos.

Pyloric resection Death

67 Leveuf¹⁹

1927 40

M. Acute perforation

Post. gastrojejunostomy

6 da.

Jejunum, opposite Pyloric resection, Billroth I Recovery

68 Porzelt⁷⁰

1927 47

M. Acute perforation

Post. gastrojejunostomy

1 yr.

None Death

69

I Robinson⁷¹

1928 31

M. Duodenal ulcer, acute perforation

Multiple ulcers.

5 yrs.

Jejunum, efferent Suture Death

70

Robinson⁷¹

1928 26

M. Duodenal ulcer

Ant. gastrojejunostomy, entero-anastomosis

7 1/2 mos.

Jejunum, opposite Pyloric resection, Kronlein-Roux anastomosis Recovery

71

I Nixon and Lowry⁶²

1928 24

M. Gastric ulcer, duodenal ulcer, acute perforations (2) simultaneous

Post. gastrojejunostomy

1 yr.

Jejunum, efferent Suture Recovery

72

III Nixon and Lowry⁶²

1928 —

M. Gastric ulcer, hemorrhage

Post. gastrojejunostomy

4 1/2 mos.

Jejunum, efferent Suture Recovery

73

Nixon and Lowry⁶²

1928 —

M. Stomach

15 mos.

Stomach

Recovery

74

Nixon and Lowry⁶²

1928 —

M. Jejunum, efferent

5 yrs.

Jejunum, efferent

Suture Recovery

75

Nixon and Lowry⁶²

1928 —

M. Stomach, multiple ulcers

6 yrs.

Stomach

Suture Recovery

76

Nixon and Lowry⁶²

1928 —

M. Stomach, multiple ulcers

Recovery

Secondary operation: Pólya resection

COLLECTED CASES—Continued

No.	Reported by Author	Year	Age in Years	Sex	Original Pathology	Original Operation	Interval	Pathology of Gastrojejunal Ulcer	Operation for Gastrojejunal Ulcer	Result	Remarks
72	Just ⁴³	1929	29	M.	Duodenal ulcer, acute perforation	Ant. gastrojejunostomy, entero-anastomosis	10 mos.	Jejunum, opposite anastomosis	Pyloric resection, Pólya anastomosis	Recovery	
73	Fromme ⁴⁴	1929	41	M.	Duodenal ulcer, acute perforation	Ant. gastrojejunostomy, entero-anastomosis	9 mos.	Jejunum, opposite anastomosis	Pyloric resection, Billroth II anastomosis	Recovery	
74	Fromme ⁴⁴	1929	32	M.	Duodenal ulcer, acute perforation	Ant. gastrojejunostomy, entero-anastomosis	77 da.	—	Pyloric resection, Billroth II anastomosis	—	
75	I Woodside ¹⁰⁰ II	1931	16	M.	Duodenal ulcer	Post. gastro-jejunostomy	4 yrs.	Jejunum, efferent	Suture	Recovery	
76	Woodside ¹⁰⁰ Steden ⁸⁴	1931	—	M.	—	—	6 yrs.	Jejunum, afferent	Suture	Recovery	
77	Steden ⁸⁴	1931	24	M.	Gastroptosis	Ant. gastrojejunostomy, entero-anastomosis	7 mos.	Jejunum, efferent	Pyloric resection	Recovery	
78	Steden ⁸⁴	1931	21	M.	Pyloric stenosis, acute perforation	Ant. gastrojejunostomy, entero-anastomosis	8 yrs.	Jejunum, afferent pyloric stenosis	Pyloric resection, Billroth II anastomosis	Recovery	
79	Steden ⁸⁴	1931	30	M.	Gastric ulcer, acute perforation	Pyloric resection	4 yrs.	Jejunum, opposite anastomosis, multiple ulcers, jejuno-colic fistula	Pyloric resection, Pólya anastomosis	Recovery	
80	Davenport ¹³	1931	35	M.	Duodenal ulcer, hemorrhage	Post. gastrojejunostomy	5 yrs.	—	Suture	Recovery	
81	Brandtner and Tonnis ⁵	1932	—	M.	Duodenal ulcer, acute perforations (2) consecutive	Pyloric resection	4 mos.	Anastomosis	Suture	Recovery	
82	Bertrand and Etienne-Martin ⁴	1933	61	M.	Gastric ulcer, acute perforation	Post. gastrojejunostomy	3½ yrs.	Jejunum, opposite anastomosis	Suture, entero-anastomosis	Recovery	
83	Dineen ¹⁶	1934	27	M.	Duodenal ulcer, hemorrhage	Pólya resection	4 yrs.	Jejunum, efferent, hemorrhage	Suture	Recovery	
84	Dineen ¹⁶ II	1934	—	M.	—	—	4½ yrs.	Jejunum, efferent	Suture, entero-anastomosis	Recovery	
85	Singer and Meyer ⁸¹	1934	42	F.	Pyloric stenosis	—	1 yr.	Jejunum, efferent	Suture	Recovery	Secondary operation: Drainage abscess
86	Singer and Meyer ⁸¹	1934	38	M.	—	Pólya resection	1 yr.	Jejunum, hemorrhage	None	Recovery	
87	Singer and Meyer ⁸¹	1934	50	M.	Acute perforation	—	3 yrs.	Jejunum, efferent, trocolic fistula	New gastro-jejunostomy	Death	
88	Singer and Meyer ⁸¹	1934	49	M.	—	Post. gastrojejunostomy	3 yrs.	Jejunum, stomal obstruction	None	Recovery	Secondary operation: Drainage abscess
89	Singer and Meyer ⁸¹	1934	43	M.	Obstruction	—	14 yrs.	Anastomosis	Suture	Recovery	

No.	Author	Year	Age	Sex	Diagnosis	Operation	Post-operative condition	Result
88	I Hinton and Church ³⁵	1934	27	M.	Duodenal ulcer, hemorrhage	Pólya resection	4 yrs. Jejunum, efferent, hemorrhage	Suture Recovery
89	II Hinton and Church ³⁵	1934	—	M.	—	Hofmeister resection	5 yrs. Jejunum, efferent	Suture Recovery
90	I Lewisohn ⁶¹	1934	53	M.	Duodenal ulcer	Pólya resection, entero-anastomosis	3 yrs. Anastomosis, stoma obstruction	Suture, entero-anastomosis Pyloric resection Hofmeister Recovery
91	II Schilling ⁷³	1935	31	M.	Duodenal ulcer	—	2 yrs. Multiple ulcers	Excision of ulcers, suture, new gastrojejunostomy Suture, resection Recovery
92	Trevor ⁸²	1935	33	M.	—	Post. gastrojejunostomy	18 mos. Jejunum, efferent	—
93	Wilkinson ⁹⁷	1935	51	M.	Duodenal ulcer	—	8 yrs. Jejunum, efferent	—
94	Toland and Thompson	1935	32	M.	Gastric ulcer	Post. gastrojejunostomy	14 mos. Jejunum, hemorrhage	—
95	Toland and Thompson	1936	42	M.	Duodenal ulcer	Excision of ulcer, post. gastrojejunostomy	4 yrs. Jejunum, efferent, hemorrhage	Disconnection Recovery
96	Toland and Thompson	1936	36	M.	Duodenal ulcer, acute perforation	Post. gastrojejunostomy	5 yrs. Jejunum, opposite anastomosis	Disconnection Recovery
97	Toland and Thompson	1936	65	M.	Duodenal ulcer, obstruction	Post. gastrojejunostomy	3 yrs. Jejunum, opposite anastomosis, hemorrhage	Suture Recovery
98	Toland and Thompson	1936	34	M.	Gastric ulcer, acute perforation	Post. gastrojejunostomy	5 yrs. Jejunum, afferent	Suture, entero-anastomosis Suture Recovery
99	Hinton	1936	37	M.	Duodenal ulcer	Post. gastrojejunostomy	8 yrs. Jejunum, efferent	Disconnection Suture Recovery
100	Hinton	1936	45	M.	Duodenal ulcer	Post. gastrojejunostomy	13 yrs. Jejunum, efferent	Death
101	Storey	1936	55	M.	Duodenal ulcer	Post. gastrojejunostomy	7 yrs. Jejunum, efferent	Suture Recovery
102	Storey	1936	44	M.	Duodenal ulcer	Ant. gastrojejunostomy, entero-anastomosis	1 yr. Jejunum, hemorrhage	New ant. gastrojejunostomy Suture Recovery
103	Storey	1936	52	M.	Duodenal ulcer, obstruction	Post. gastrojejunostomy	5 yrs. Jejunum, efferent	Suture Recovery
104	Storey	1936	47	M.	Duodenal ulcer, obstruction	Post. gastrojejunostomy	2½ yrs. Jejunum, opposite anastomosis, hemorrhage	Suture Recovery

effect of the acid gastric juice plays a highly important rôle in the production and perforation of gastrojejunal ulcer.

Treatment.—The data which we have collected amply illustrate the efficacy of surgical treatment and the futility of expectant treatment. As against a mortality of 90.9 per cent in the untreated cases, the highest mortality in the treated cases was 28.5 per cent. While the numbers of cases in some of the operation groups are admittedly small, the mortality rates, we believe, are significant. Disconnection of gastrojejunostomy appears to be the safest procedure and probably should be carried out when the patency of the pylorus will permit. Simple suture carrying a mortality of 17.6 per cent and requiring more secondary operations than the other procedures is by virtue of its simplicity applicable to the largest number of cases. This fact alone would tend to make the mortality for this operation appear high. Gastrojejunostomy, which has a mortality in this series of 25 to 28.5 per cent, appears, in view of our other findings, as not only ineffectual but perhaps meddlesome, except in cases wherein pyloric obstruction coexists. The most remarkable finding with respect to treatment of acute perforation of gastrojejunal ulcer was the fact that in 17 cases wherein pyloric resection was carried out there was only one death, representing a mortality of 5.6 per cent.

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LATE RESULTS IN ACUTE PERFORATED PEPTIC ULCER TREATED BY SIMPLE CLOSURE

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THIS investigation was undertaken with the primary object of ascertaining late results in cases of acute perforated peptic ulcer treated by simple suture alone. It is based upon a series of 74 such cases operated upon at the Beekman Street Hospital during the years 1926-1932, inclusive. Cases treated by other methods and a few who refused operation are omitted. Otherwise this represents a consecutive series. A postoperative interval of at least 12 months was required in each case considered; in the majority of cases at least three years had elapsed since operation.

In endeavoring to obtain a comprehensive and first hand estimate of late results, an attempt was made by the author to interview and examine each case personally. Of 66 letters sent out for this purpose, 26 patients came in for interview and examination. There were in addition six patients who had recently been seen in our regular follow-up clinic so that we had, through examination, recent information about 32 of the 66 who survived operation, making a total of 48.4 per cent followed over a period of one to six years and recently examined.

To 34 cases with whom a special interview could not be arranged, a questionnaire was sent. Of this number two subsequently came in for examination, and of the remaining 32, 13 replies were received. While it is appreciated that information obtained by questionnaire usually has not the value of that resulting from direct follow-up examination, being at times even misleading, in composing the questionnaire an attempt was made to elicit replies which would be comprehensive and pertinent. It was gratifying to find that the replies were in the main complete, earnestly filled in and in many instances accompanied by letters which gave additional information that proved of value. The author believes that the benefit of this type of late study, seriously conceived, tends to be underestimated.

Adding to the 32 cases recently examined the 13 replies to questionnaire,

TABLE I
FOLLOW-UP STATISTICS

	Number	Per Cent
Total cases surviving operation.....	66	
Special follow-up examination.....	26	39.3
Recent examination.....	6	
Total examined recently.....	32	48.4
Questionnaire replies.....	13	
Total late follow-up.....	45	68.1

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late information was obtained in 45 of the total series of 66 survivors, 68.1 per cent (Table I).

While primarily undertaken to determine late results, analysis of case records in this study revealed many other interesting points which merit some consideration.

Sex.—It was somewhat surprising that all of the 74 patients in this series were males, and it might be added that, in going over all the records of the Beekman Street Hospital during the last ten years, not a single case of acute perforation of peptic ulcer was found occurring in a female. Review of the literature on this subject shows males predominating by a striking majority, usually the ratio being about 10:1, but in no other considerable series was the female sex altogether excluded.

Incidence by Years.—Of the total 74 cases, distribution by years is shown in Table II.

TABLE II

INCIDENCE BY YEARS

1926.....	11
1927.....	11
1928.....	14
1929.....	13
1930.....	9
1931.....	11
1932.....	5
<hr/>	
Total.....	74

There is seen to be a distinct decrease during the latter three years of this study. The explanation of this drop in numbers is not obvious, since the total hospital census during this period showed no proportionate change. It is suggested that increased unemployment since 1929 with less hurry and physical tension on those engaged at their occupations may be factors of some importance in the lessened incidence of ulcer perforation. It may be also that the public as a whole is becoming more "stomach conscious" in view of cancer campaigns of recent years, with the result that stomach lesions are being recognized earlier and are less frequently neglected to the point of perforation. That this latter is not the full answer, however, is evidenced by the fact that a few cases were encountered in the present series where perforation occurred in persons at the time actually under some dietary regimen for known ulcer. This finding is in accord with the experiences of Hinton¹ who reported six cases of acute perforation which occurred in patients under active treatment for chronic ulcer.

Seasonal Incidence.—Tabulation of cases by months disclosed no seasonal incidence of perforation. They occurred more frequently in October and December, and were less in April, June and August, but on the whole there was no significant variation between the months.

Age Incidence.—The youngest patient in this series was 19; the oldest 67,

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there being two cases of this age, both of these incidentally being fatal cases. By decades, the 30-40 age period showed by far the largest number, the 40-50 period being next in frequency (Table III).

TABLE III
AGE INCIDENCE

10-20.....	1
20-30.....	16
30-40.....	26
40-50.....	17
50-60.....	10
60-70.....	4
Total.....	74

Location of Ulcer.—Contrary to our general impression prior to this review, the majority of the acute perforations were found in gastric ulcers, 41 being situated proximal to the pylorus. There were 26 lesions in the duodenum and seven were found at the pylorus. No multiple perforations were encountered. All the duodenal perforations in this series were on the anterior surface or superior border of the intestine. Of the stomach perforations, four were through its posterior wall into the lesser cavity. In these cases, as a rule, development of symptoms was later and the diagnoses more difficult. The remainder of the stomach lesions were about equally divided between the lesser curvature and the anterior surface. There was none noted on the greater curvature.

Previous Gastric History.—Not many years ago it was generally held that most peptic ulcers which resulted in perforation were acute ulcers, differing in type from the chronic peptic ulcer, being of relatively recent origin and preceded rarely by continued dyspeptic symptoms. More recently this opinion has been questioned though it still appears to have its adherents. In our series only 12 of the 74 patients gave a negative past gastric history, the remaining 62 or 86 per cent admitting more or less typical ulcer symptoms, varying in time from a few weeks to many years. These histories corresponded well with the operative findings. In only eight cases was there reported to be no, or slight, induration about the perforation as seen at the operating table. Eleven, or slightly over 15 per cent, of all the cases gave histories of previous nonoperative ulcer treatment. Two cases had had earlier acute perforations, one of these two having perforated twice previously (Table IV).

TABLE IV
HISTORY OF PREVIOUS GASTRIC COMPLAINT

Total No. Cases	Cases with Previous Gastric History	Cases Having Previous Nonoperative Ulcer Treatment	Cases with Previous Perforation	Operative Finding of Induration
74	62 (86 per cent)	11 (15 per cent)	2	58 (78 per cent)

Diagnosis.—The matter of diagnosis presented relatively little difficulty in this series. In 63 of the 74 cases the clinical picture was typical and the diagnosis was readily established. Of the remaining 11 cases the possibility of acute appendicitis was entertained in four cases, acute cholecystitis in three and acute pancreatitis in one. Since all of these eight cases were recognized and regarded as acute surgical emergencies, the possibility of perforated ulcer being considered in each, early operation was performed. The remaining three cases offered more difficult diagnostic problems. Each was admitted first to the medical service, two with the preliminary diagnosis of coronary artery disease and the third as intestinal neoplasm with partial obstruction. In each of these cases there was a delay of 24 hours or more before operative intervention, and all three proved eventually to be fatal cases.

Preoperative flat roentgenologic study as a diagnostic aid has proven of indifferent value to us. Flat abdominal films were taken in 32 cases and in 10 free gas was demonstrated; the remaining 22 gave negative results. Definite roentgenographic indication of right diaphragmatic elevation by gas is a most reliable diagnostic aid, but negative roentgenographic findings occur frequently and must be disregarded.

Operation.—The 74 operations were performed by nine different surgeons. All were simple closures, usually with purse-string suture, although a few were by mattress or figure of eight sutures. As a rule there were three suture layers; the first of catgut through all walls of the viscus, the second and third of linen not including the mucosa. An omental tab was usually included in the third suture layer. In three cases only a single suture layer was employed, one of these cases resulting fatally. Only six of the 74 cases were drained. In many instances there appeared to be great distortion and probable pyloric constriction after the plication closure. However, side-tracking or plastic procedures to obviate possible pyloric obstruction were deliberately withheld and in no case did interference with patency of the pylorus develop. Our experience shows that most of the apparent deformity disappears as the local inflammatory edema subsides.

General anesthesia was used more frequently than spinal in the total series, the ratio being 50 to 23. In the latter years, however, spinal and general anesthesia were about equally popular. One case was performed under local abdominal wall infiltration with novocain.

Immediate Results—Operative Mortality.—There were eight deaths in this series of 74 cases, an operative mortality of 10.8 per cent. No death occurred in a patient under the 30–40 year age period, the highest relative mortality being found in the 50–60 and 60–70 decades. Anatomic location of the lesion was not important, there being fairly equal distribution among the fatal cases: three gastric, three duodenal, and two pyloric. The type of anesthetic also seemed a relatively unimportant factor in mortality. There were deaths in three cases operated upon under general, four under spinal and one with local novocain, the latter in a very poor operative risk.

As was expected, we found that the patient's chances of surviving depended chiefly upon how soon after perforation his operation was begun. This relationship is shown strikingly in Table V.

TABLE V
MORTALITY AND ITS RELATION TO TIME OF OPERATION

Duration of Perforation	No. of Cases	No. of Deaths	Mortality Per Cent
6 hrs.....	49	1	2
6-12 hrs.....	13	2	15
12-48 hrs.....	10	3	30
Over 48 hrs.....	2	2	100
All cases.....	74	8	10.8

Experiences of Other Authors.—An extensive literature is to be found on the study of the general subject of acute peptic ulcer perforation. No attempt will be made, however, to present at this time findings of other authors except as they deal, at least indirectly, with late results. Although generalizations and impressions are found frequently expressed, studies with follow-up findings based upon direct examination and presenting criteria for analysis and specific findings are relatively few.

As is commonly seen on clinical investigation of similar subjects by different authors, no great unanimity of findings or conclusions exists in this field. This divergence of opinion may be explainable in part on the basis of local racial, geographic and dietetic variations. The type of primary operative procedure may also be a factor. But it seems most likely that lack of uniformity in evaluating results is the most important reason for this diversity of findings.

As regards the type of operative procedure to be employed for acute perforation, simple closure usually without peritoneal drainage seems now to be the method of choice in this country (Gibson,² Stewart and Barber,³ Colp,⁴ White and Patterson,⁵ Pool and Dineen,⁶ St. John,⁷ Farr⁸). The British authors also, in recent years, have been favoring plication closure alone (Gilmour and Saint,⁹ Bryce,¹⁰ Black¹¹). Urrutia¹² almost alone of continental European surgeons has been an advocate of this method. On the other hand, Deaver¹³ urged the necessity of the addition of primary gastrojejunostomy to the closure, and this procedure is followed by many surgeons here and abroad (Walton,¹⁴ Alexander,¹⁵ Mills¹⁶ H. P. Brown¹⁷). Still other writers have advocated primary anastomosis in most cases, though not as a routine (Scotson,¹⁸ Shelley,¹⁹ Platou,²⁰ Boyd²¹). In perforation of duodenal ulcers Moynihan²² adds gastro-enterostomy to suture closure. For lesions situated at, or just proximal to, the pylorus he recommends excision of the ulcer with added pyloroplasty. So also does Söderland²³ who urges excision of the ulcer margins before suture closure in all cases. Pyloroplasty is advised by Hinton,²⁴ and H. P. Brown²⁵ in cases where primary gastro-enterostomy is not done. Kuntz²⁶ in some cases combines jejunostomy with simple closure, although he performs gastric resections in most instances.

In recent years more radical immediate measures for the treatment of acute ulcer perforation have been employed by central European surgeons. Particularly in the large German and Austrian clinics, primary gastric resection for perforation is now widely practised. Recently Graves²⁷ compiled a large series of such cases operated upon by several German surgeons, his findings indicating a lower immediate mortality rate with resection than with simple closure alone. However, in interpreting these results it must be realized that in this series the simple procedure usually was reserved for patients who were obviously bad operative risks. Many other reports of primary resections are to be found from foreign sources, some of the more recent of these being by Hromada and Newman,²⁸ Schwarz,²⁹ Kreuter,³⁰ Eichelster,³¹ Judine,³² Peters,³³ Ciancarelli,³⁴ and Kuhlman.³⁵ In this country gastric resection for acute perforation is rarely advised. The author recently performed such resection in a patient with multiple perforations with good result, and believes this procedure is indicated in some cases.

Considering now the question of published late results alone, reports as found in the literature show a wide divergence of findings and opinion. Thus Stewart and Barber³ after simple closure reported their patients "in most instances cured or improved" and Walton¹⁴ found "not a single recurrence" of symptoms in those who survived operation when primary gastro-enterostomy was performed. Gibson,² in a study of 93 patients, followed after operation, had 41 "excellent" and 31 "satisfactory" results. However, it is found on analysis of his statistics that, of the remaining 21 cases, 19 had symptoms sufficiently severe to require reoperation and of those reported as having good results two later had reperforation. Dineen³⁶ found 80 per cent of his cases to have good results and in an earlier study with Pool⁶ reported 60 per cent to be satisfactory after simple suture alone. Employing the same operative method, White and Patterson⁵ had 60 to 65 per cent "cure" of ulcer symptoms in a small series of cases. St. John⁷ also reported favorable late results, finding 59 per cent symptom-free, and Farr⁸ in a larger series found nearly 70 per cent good results after plication closure of acute perforation. Collinson³⁷ reported 65 per cent good late results. Southam³⁸ found 28 out of 37 cases to be satisfactory. On late investigation of 59 cases in which some had gastro-enterostomy in addition to simple suture, Shelley¹⁹ found recurrent symptoms in only 32 per cent. K. P. Brown³⁹ states that over 60 per cent of his patients had no further trouble, the percentage of favorable cases being even higher in those who had primary gastro-enterostomy. Similarly Platou's²⁰ experience was favorable when he employed anastomosis at the time of operation for the perforation, all 14 of his patients so treated having had no further trouble. In reporting a group of 90 compiled cases, all of whom had primary gastro-enterostomy, Luff⁴⁰ states that over 68 per cent had "no pain or discomfort." These cases were not personally examined by him; also he does not give the time interval of the follow-up. Similarly vague is the report of Rhodes and Collins,⁴¹ who found that 85 per cent of patients followed "reported themselves either entirely free of ulcer

symptoms, or evidences of recurrences were promptly controlled by dietary measures." Again there is no statement of the postoperative interval nor criteria used for evaluation of results.

In contrast to the above reviewed favorable reports are the experiences of other writers who found recurrent ulcer symptoms in many of their patients who had recovered from operative procedures directed towards the treatment of acute perforation. Lewisohn,⁴² through personal late examination, in 33 cases found 13 "failures," five of these subsequently coming to reoperation. Williams and Walsh⁴³ reported that of eight patients with gastric ulcer perforation on whom late information was obtained, five had come to reoperation; of their duodenal cases 53 out of 94 had required further surgical treatment. Gilmour and Saint⁹ in their analysis of 48 cases with late follow-up report 61 per cent recurrence of ulcer symptoms. In Platou's²⁰ series of 25 patients, after simple closure alone, 16 had recurrent ulcers. Of these 16, eight later had gastro-enterostomy performed and three others had reoperation. Morley⁴⁴ found that 17 out of his 41 cases, studied late, required further treatment for ulcer. Similarly Bryce¹⁰ in 100 cases had only 32 free of gastric complaints. These experiences correspond to those of Scotson⁴⁵ who reports recurrent symptoms in 58 per cent of 92 cases. Similar also are the findings of Urrutia.¹² After late study this author reports recurrence of ulcer in 50 per cent of the cases treated by simple closure. After added gastro-enterostomy he found even more recurrences, only one out of three so treated being cured of ulcer in his experience.

Criteria for Evaluation of Late Results.—In dealing with patients presenting a gastric disorder, the accurate evaluation of late results is by no means easy. We must depend for our information primarily upon the patient's replies to questions about his subjective state. Tangible physical findings are few. Occasionally local tenderness may be found but its absence does not rule against the persistence of active pathology. Late roentgenographic studies were obtained in a few cases but it was not felt that sufficient information could be obtained in this way to warrant its being employed in the entire series. The expected postoperative deformity was seen in those cases so studied, but differentiation between active ulcer and cicatricial deformity particularly in the pyloric region could not be made with assurance. Gastric analyses also were not generally employed, since it was felt that this procedure would not materially aid us in evaluating results. In the main we had to depend primarily on the histories we could obtain.

We have then no yard stick by which to measure accurately the status of these patients. With criteria for recurrence or cure based largely upon subjective standards one cannot hope to grade results except in a gross way. Conclusions in any such study, if the attempt is made to tabulate results too finely, are liable to be misleading or unfair, no matter how earnest or sincere is the investigator.

We decided, therefore, to classify our postoperative results in a rough way, as good, bad or fair. In judging and gauging replies to our queries,

an attempt was made to evaluate in so far as possible the types of personalities with which we were dealing, to size up each individual and weigh his responses fairly. We have taken some time to clarify our standards, which we regard of prime importance in this type of study. Differences by various authors in criteria for cure and recurrence have caused much confusion in the literature.

Results classified as "good" were those in which patients had remained symptom-free after a period of reasonable dietetic and hygienic care. Such persons were expected to have returned to their usual occupations, or to have been able to do so, if the desire or opportunity were present. Preoperative weight and strength should have been regained and retained.

We regarded as "poor" results those cases which reported periodic or persistent recurrence of ulcer symptoms where these symptoms appeared real in origin and significant in amount. Any who required further medical or or surgical treatment for peptic ulcer were given this classification. Patients who had been reoperated upon were of course placed in this category. Cases with roentgenologic findings of new lesions or disturbances of gastric motility were put in the "poor" column.

In our final classification of "fair" results were included those patients whose complaints were mild, inconstant and not entirely typical of ulcer. Where symptoms were persistent, but appeared to be in large part functional or based on sociologic or economic dissatisfaction, the result was considered fair. Those individuals with recurrent complaints who admitted ignoring or seemed to have disregarded postoperative instructions soon after leaving the hospital were regarded as having fair results unless their symptoms were of more than moderate severity.

Analysis of Late Findings and Results.—By these standards, of the 32 who had recent follow-up examination, 15 were classified as having poor results, six as fair and nine as good. Recurrence of symptoms in this group was found in 23 of the 32, or 71.7 per cent. Similar evaluation was attempted in those heard from by questionnaire only. Of these 13 cases the results in five were considered poor, one fair and seven good, giving six or 46 per cent with recurrence of symptoms. Altogether of the 45 cases about whom we had recent information, 29 were found to have had significant further gastric trouble, a recurrence in the series of 64.4 per cent.

It is interesting to note that of these 45 cases who were followed over a one to six year period after perforation, five have had subsequent reoperation, three for a second acute perforation (the third perforation for one patient). One had a gastro-enterostomy six months postoperative for obstruction and one a gastric resection for persistent symptoms. This one case with gastro-enterostomy was the only one we know of in our entire series in whom pyloric obstructive symptoms developed after plication closure alone for acute perforation, this despite frequent gross distortion of the pylorus immediately after the closure.

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TABLE VI

ANALYSIS OF END-RESULTS

	Number of Cases	Poor	Fair	Good	Total Recur- rences
Special examination.....	26	12	6	8	} 23 (71.7 per cent)
Recent follow-up examina- tion	6	3	2	1	
Questionnaire cases.....	13	5	1	7	6 (46 per cent)
Total examinations plus questionnaire cases.....	45	20	9	16	29 (64.4 per cent)

SUMMARY.—(1) A study is presented of 74 consecutive cases of acute perforation of peptic ulcer treated by simple closure alone.

(2) These cases were all from the Surgical Services of the Beekman Street Hospital, operated upon during the years 1926-1932, inclusive.

(3) It is interesting to note that all of these patients were males, and that during the last ten years not a single female has been admitted to the Beekman Street Hospital with this complication.

(4) During the latter three years embraced by this study, there has been noted a rather sharp drop in the incidence of ulcer perforation. The cause of this decrease is not clear; several possible factors are considered.

(5) No significant monthly or seasonal variation was found.

(6) By far the largest number occurred in the 30-40 year age period.

(7) Gastric perforations were more frequent in this group than were duodenal or pyloric, the anatomic distribution being gastric 41, duodenal 26, pyloric seven.

(8) Of the 74 patients, only 12 had been entirely free of "dyspeptic" symptoms prior to perforation. The remaining 62 or 86 per cent gave a definite antecedent gastric history. Eleven of these had had previous medical ulcer treatment with two having had earlier simple closure for acute perforation. One patient had perforated twice previously.

(9) The majority of cases were seen early after onset of acute symptoms, 49 or 65 per cent having been operated upon within six hours from the estimated time at which perforation occurred.

(10) On the whole diagnosis was made easily; 63 of the cases presented no diagnostic problem.

(11) Flat abdominal roentgenologic study proved to be only an indifferent diagnostic aid. It is valuable only when free subphrenic gas can be demonstrated. A negative finding has little significance.

(12) Operation consisted almost invariably of three layer purse-string closure of the perforation. Peritoneal drainage was rarely employed.

(13) Eight of the 74 patients died after operation, a general operative mortality of 10.8 per cent. Neither anatomic site of the perforation nor choice of anesthetic was found to be a factor of consequence in mortality in this series.

(14) Mortality percentage rose directly and sharply with delay in commencing operative interference.

(15) The literature dealing with late results in acute ulcer perforation is reviewed.

(16) The author's criteria for evaluating late results are presented in detail.

(17) Through combined special examination and replies to questionnaire, late study was obtained in 45 of the total 66 patients who survived operation, giving recent information in 68.1 per cent of these cases. The follow-up period was over a one to six-year period.

(18) Altogether of the 45 cases, about whom we had recent information, 29 were found to have had significant further gastric trouble, a recurrence in this series of 64.4 per cent.

CONCLUSIONS

(1) The low mortality rate and excellent early results, with simple closure alone, warrant the routine use of this procedure in the emergency treatment of acute peptic ulcer perforation.

(2) Addition of gastro-enterostomy for mechanical reasons is rarely necessary, no matter how extensive the induration or how great the apparent pyloric distortion after plication.

(3) Acute perforation followed by successful closure results in permanent cure of ulcer in only a minority of cases.

(4) In almost two out of three cases peptic ulcer symptoms recur later with complaints of greater or lesser severity.

(5) All cases of ulcer perforation deserve postoperative follow-up study and in most instances further medical or surgical care is required.

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OBSTRUCTIONS ABOUT THE MESENTERY IN INFANTS*

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REPEATED vomiting in infancy is always a cause of great concern to the parents and to the attending physician. When the baby cannot retain his feedings in the first weeks of life the usual procedure is to try various modifications in the diet. If after several failures, and the response even to thickened feedings and atropine therapy is without result, an organic obstruction of some type is likely to be found the underlying cause. The most common etiologic factor of organic obstruction in infancy is hypertrophic pyloric stenosis. But there are a certain number of obstructions which make their presence known almost as soon as the baby takes anything by mouth. These obstructions can be differentiated from hypertrophic pyloric stenosis. They occur in or about the duodenum and are usually in close anatomic relationship to the mesentery of the small intestine. We wish to consider this group of obstructions in this communication. The group includes the duodenal atresias; the internal herniae; and the anomalies due to faults in migration, descent and fixation acting on the first portions of the small intestine.

The earliest recorded case of congenital intestinal occlusion is credited to Calder who, in 1733, according to Cordes^{1†} described an atresia of the duodenum. In 1901, Cordes collected from the literature only 56 cases of duodenal atresia and stenosis. Two years later Kuliga² made an extensive study of congenital occlusions of the entire intestinal tract based on 189 reported cases. In 1922, Davis and Poynter³ increased this number to 392. In other words, the reported cases averaged two per year over a period of approximately 200 years, which gives a false impression of the frequency with which the condition occurs. While congenital intestinal anomalies leading to complete and partial obstruction are unusual, they are not rare. Ladd,^{4, 5} who reported 60 cases from the Children's Hospital of Boston, states that the fact that he has "encountered ten cases in a comparatively short time makes me feel that they (congenital anomalies) have been overlooked in the past." He feels that the "frequency of postmortem reports of the cases and the infrequency of these conditions in adult life indicate a high mortality without surgical intervention."

Since Cordes' contribution other reports stressing various phases of congenital occlusions have appeared. Among these should be mentioned those of Pehu and Auberge,⁶ Thorndike,¹³ DeSanctis and Craig⁷ and most re-

* Read before the American Surgical Association, Chicago, Ill., May 7, 1936.

† 1752 according to Davis and Poynter.³

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cently Ladd. Spriggs⁸ gives an excellent and detailed description of the microscopic findings in cases of stenoses, as do Davis and Poynter. The latter feel that the fundamental etiologic factor is primary sclerosis of the regional vessels, the changes in the bowel wall being secondary to the resulting circulatory disturbances.

Congenital intestinal occlusions are commonly classified as intrinsic and extrinsic. The pathology of the atresias varies from a complete absence of a portion or portions of the intestine to all grades of intestinal fibrosis and diaphragms occluding the lumen. Atresias occur more commonly in the duodenum than in any other part of the gastro-intestinal tract, 30 per cent according to von Koos⁹ and Davis and Poynter. The extrinsic occlusions form an interesting group and it may be said that in general they result from faulty or incomplete intestinal rotation and hyperperitonealization during fetal development. Internal herniae as a cause of obstruction are encountered less frequently than short mesenteric arteries, incomplete intestinal rotation, abnormal peritoneal bands and adhesions.

An understanding of the embryologic development with the changes in anatomic relationships of the gastro-intestinal tract will help the surgeon to untangle these complicated anomalies which he encounters at operation. A fairly accurate picture of the process has been pieced together for us by studies on human embryos and from observations in comparative anatomy.¹⁸ It is presented as a theoretical motion picture although the evidence is made up from a series of still exposures often with great unfilled gaps between. When one realizes the many opportunities that there are for something to upset the orderly progression it is amazing that these anomalies are so relatively uncommon.

The stomach moves down from the cervical into the lower thoracic region during the sixth and seventh week of embryonic life. It hangs vertically with a right and a left surface until a more rapid growth of the dorsal or posterior border and its mesentery takes place. This inequality in growth rate leads to the development of a relatively freely movable greater curvature and a relatively fixed lesser curvature. The fundus also evolves as an outpouching on this dorsal border. The resulting disproportion between the anterior and posterior border of the stomach leads to a rotation, the greater curvature moving towards the left. The former right surface finally becomes posterior and the left surface anterior in position. During this same time the duodenum is giving rise to the buds which develop into the liver, biliary passages, and the pancreas. The duodenum then becomes occluded by proliferation of its lining epithelium. It remains in this condition so that the lumen is blocked until the sixth week. Then, normally, the epithelium is absorbed again. In rare instances this does not occur but the epithelium becomes organized. This mechanism results in the various types of atresia encountered in the duodenum as well as elsewhere in the jejunum and ileum. These atresias may be single or multiple, partial or complete. The occlusion may be a solid cord of some extent or a simple membrane. Cases 1 and 2 illustrate this type of anomaly. Atresia in the duodenum frequently occurs

just above the opening of the common duct, but we have not met such a case in our series.

The mobile duodenum undergoes a rotation and fixation of its own from the sixth to the ninth week. It is forced towards the right side of the abdomen by the rotation of the stomach, and there twists on its axis. This causes an alteration in the position of the common duct and the pancreatic outgrowths so that they occupy more nearly their adult positions. The duodenum then becomes fixed to the region of the gallbladder and liver, fused with the dorsal wall, and suspended behind the root of the mesentery by a fibromuscular band, Treitz's ligament. The superior mesenteric artery thus passes in front of the terminal part of the duodenum.

That portion of the intestinal tract supplied by the superior mesenteric artery—the midgut—starts out as a U loop within the umbilical cord. In the sixth week of life the cecal bud becomes apparent. By the ninth week coils of lower jejunum and ileum have formed in the cord and an upper jejunal coil distal to the duodenojejunal attachment. The loops in the cord are drawn into the abdominal cavity by retraction bands in the mesentery during the tenth week. The operation of rotation of the bowel which is necessary before its fixation takes place appears to be greatly helped by its shape and position in this special umbilical sac. The portion of the midgut from the duodenum to the vitelline artery passes in behind the artery from right to left. The portion of the midgut from the vitelline artery to the midtransverse colon passes in front of the artery from left to right. By the third month the U shaped loop has become twisted around the axis of the superior mesenteric artery.

The hindgut is drawn up and molded into place by pressure of the small bowel against it. It usually fuses with the posterior wall assuring its fixation. Towards the end of the third month the large bowel occupies an oblique position across the abdomen from the right iliac crest to the left hypochondrium. The rotation has brought the mesentery of the cecum and ascending colon into contact with the duodenum. The cecum thus comes to rest in front of the lower part of the right kidney near the gallbladder in the majority of fetuses. It remains there until about the time of birth. At the time of birth the ascending colon moves toward the right iliac fossa, elongating in the process—descent. The liver and the gallbladder move upwards providing more room for fixation of the ascending colon at the hepatic flexure. The adhesions which the ascending colon forms in its fixation, just before and just after birth as the cecum descends to its final position, offer many opportunities to produce anomalies.

If there are unequal tension pulls on the retroperitoneal duodenum it may be angulated or twisted on itself, especially since it may be caught between two opposing forces—those causing its firm anchorage at Treitz's ligament and those pulling towards the right iliac fossa. Under these conditions it is not strange that we have encountered such partial obstructions as are recorded in Cases 5, 6, 7, 8, and 9. These result from hyperfixation

of the peritoneum about the duodenum giving partial obstructions from plications or torsions of its lumen. In Cases 10 and 11 we have examples of obstructions due to failure in descent of the cecum. These patients presented an exact duplication of the position and attachments of the great bowel at the end of the third month of development. But their close attachments prevented the duodenum from functioning properly, especially in Case 11 where a well formed cystocolic membrane was exposed. In Case 4 we have a most interesting example of one of these developmental anomalies. It is classed as a retroperitoneal hernia by most surgeons. We believe that it represents an abnormal fixation of the mesentery. When the rotation occurs in a direction opposite to the normal, the duodenum and mesentery come to lie in front of the transverse colon instead of behind it. These cases are a great puzzle to the surgeon unless he can expose the root of the mesentery. Then, the whole bowel unrolls rapidly. At the finish of such an operation all the small bowel will occupy the right and all the large bowel the left side of the abdominal cavity. This is the condition as it is in development before any rotation has taken place.

When there is failure of complete fusion at the duodenojejunal junction, a deep fossa may be left into which jejunum may herniate. Case 3 is an example of a very unusual herniation into the lesser peritoneal cavity through such an opening.

Herniation of the small intestine into the lesser peritoneal cavity is uncommon. Moynihan,¹⁰ in his monograph on retroperitoneal hernia, cites only four cases. The bowel gains access to the lesser peritoneal cavity by two routes, the more common being through the foramen of Winslow. Dewis and Miller¹¹ reported 34 cases. Less frequently as in the present case, herniation occurs through the transverse mesocolon. Heaney and Simpson¹² reported 21 cases of this type. The herniated intestine may remain in the lesser peritoneal cavity or it may partially emerge by forcing itself through the gastrohepatic or gastrocolic omentum to again occupy, more or less, its normal position in the abdominal cavity. Occasionally herniae through the transverse mesocolon emerge through the foramen of Winslow.

In reported cases increased intra-abdominal pressure due to vomiting caused by associated lesions (ulcer or carcinoma of duodenum and stomach) was felt to be responsible for producing a tear in the transverse mesocolon. Its occurrence in adult life makes it probable that in most instances it is an acquired lesion. There seems to be little question that in the present case the defect in the mesocolon was congenital.

CASE REPORTS

Case 1.—No. 34798. E. S., a white female infant, the fourth in the family, was born in the Strong Memorial Hospital, May 1, 1930. The father and mother were healthy with negative Wassermanns. The pregnancy had been normal, the delivery spontaneous, and at birth the child was apparently normal weighing 2,600 Gm. (5.7 lbs.). The patient was seen in consultation by the pediatricians on May 3 because of vomiting and failure to pass urine and meconium. Vomiting started 48 hours after birth. Regurgitation

was frequent, occurred immediately after feeding and on some occasions consisted of a thin brownish fluid containing "coffee ground" material.

Physical examination showed a dehydrated female who appeared normal. Abnormal findings were limited to the abdomen which was thin walled and distended in the epigastrium but scaphoid in the lower abdomen. A sausage shaped mass extended diagonally across the epigastrium from the left costal margin to the right flank about on a level with the umbilicus. Across this mass peristaltic waves were visible, passing usually from left to right but occasionally from right to left. The mass was soft and doughy. The liver edge was palpable 1 cm. below the costal margin. No other masses were palpable. Bladder dulness was not increased to percussion.

Frequently repeated subcutaneous saline infusions were given. A catheter introduced into the rectum passed readily without encountering an obstruction. A small amount of normal saline which was introduced was readily expelled and with it a thick tenacious plug or cord of meconium 10 cm. in length. Following this more meconium was passed. The size of the abdominal mass remained unchanged. On May 4, the third day, the signs and symptoms were unchanged. A barium enema showed the colon patent and filled up to the hepatic flexure. At this point there was a "redundant loop of bowel distended with gas." The barium did not fill the ascending colon or cecum. The patient was first seen by the surgeons May 5, the fourth day, at which time her condition was grave. She was almost moribund. Her weight was 2,260 Gm. (4.95 lbs.), a loss of 340 Gm. (.74 lbs.). The temperature was 35° C. The abdominal signs were unchanged.

Operation was performed immediately under ether anesthesia, a right rectus incision being made. The stomach and duodenum were tremendously distended, the diameter of the latter being about 8 cm. and its walls of tissue paper thinness. The duodenum was bound down by abnormal peritoneal bands which were released. The transverse colon and stomach were reflected upward and Treitz's ligament identified. The jejunum appeared normal though small, being about the size of an ordinary lead pencil. Dilatation of the duodenum was found to extend to the third portion at the point where the superior mesenteric vessels crossed, these having been reflected upward and any possible constricting effect there relieved. Gentle pressure was exerted on the dilated duodenum but no gas passed beyond the point of obstruction. It was thus apparent that the obstruction was intrinsic in the retroperitoneal portion of the duodenum and due either to an occluding membrane or an atresia. Relief of the obstruction depended upon a short circuiting anastomosis. Duodenojejunostomy, the logical procedure, was considered inadvisable and almost impossible due to the thinness and delicacy of the duodenal wall as a result of distention. It was questionable if the thinned out walls would hold the sutures. A posterior gastro-enterostomy was performed without clamps, using silk sutures throughout. The stoma was approximately 4 to 5 cm. The patient's condition at the end of the operation was poor.

The immediate postoperative recovery was excellent. The temperature rose to 39° C. the day after operation, returning to normal on the third day. Subcutaneous saline infusions were given regularly. Feedings were started the day after operation. The patient vomited once and thereafter feedings were given by gavage; there was no further vomiting. She took the bottle on the third day after operation and from then on progressed satisfactorily. She regained all weight lost and when discharged 15 days after operation weighed 2,620 Gm. (5.7 lbs.). A normal stool was passed on the second day after operation. Urinary function became normal. A gastro-intestinal series two days before discharge showed a dilated stomach and a well functioning gastro-enterostomy (Fig. 1).

Unfortunately, it was soon recognized that the patient was a Mongolian idiot. Her course from the gastro-intestinal standpoint was entirely satisfactory for one year. Irregular attacks of vomiting and diarrhea occurred about a year after operation. These

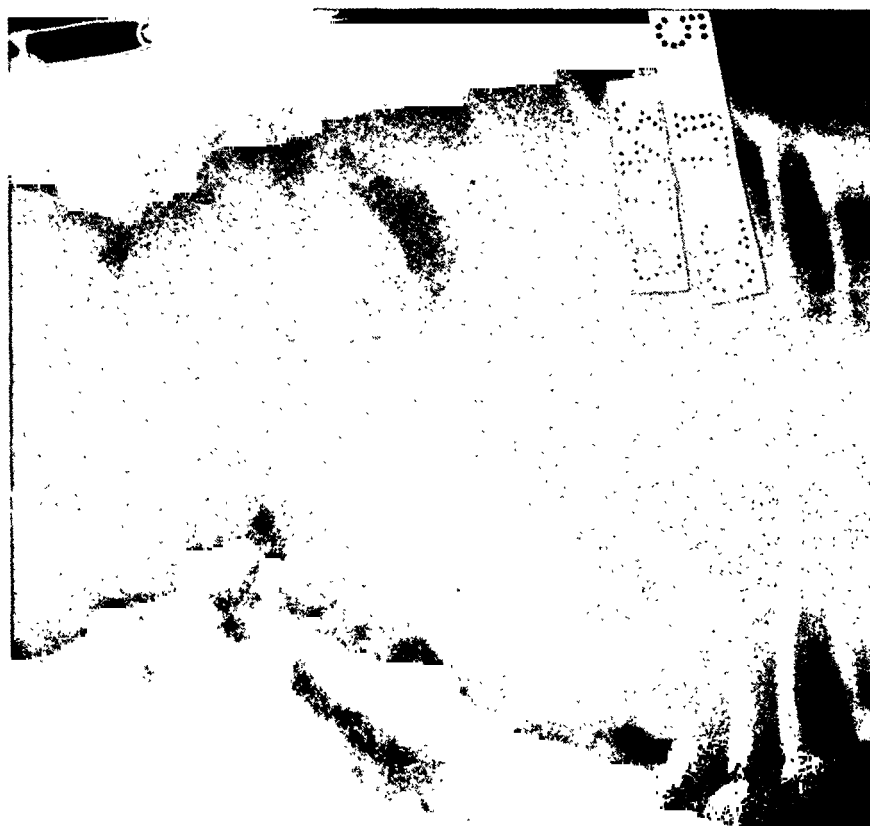


Fig. 1.—Case 1. Roentgenogram showing a dilated atonic stomach and duodenum. Taken after gastro-enterostomy.

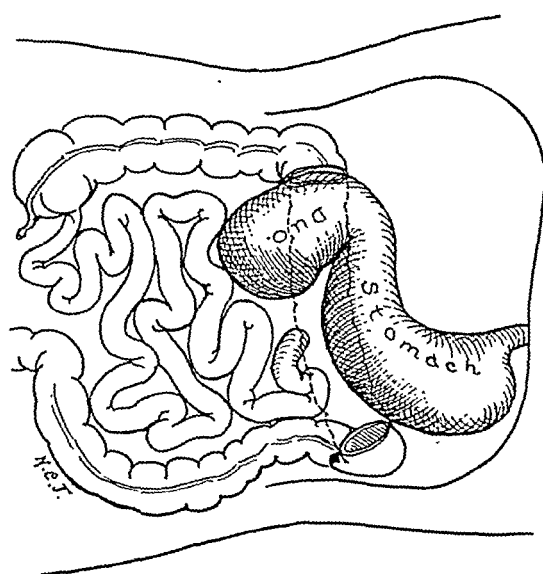


Fig. 1a.—Case 1. Atresia of duodenum. Condition found at operation. Absence of third part of duodenum. Confirmed at autopsy two years later.

persisted for a period of one or two months and then ceased. In January, 1932, 20 months after operation, she was readmitted to the hospital with a diagnosis of pneumonia, to which she succumbed.

Postmortem examination showed bilateral bronchopneumonia, acute bronchitis, bilateral otitis media, acute splenic tumor, atresia of the duodenum with complete absence of the third portion, a healed, patent gastro-enterostomy and a patent foramen ovale.

Case 2.—No. 61269. J. L., an apparently normal female, the fourth child, born in the Strong Memorial Hospital, May 22, 1932, began vomiting on the fifth day. Changes in formula, antispasmodics, *etc.*, failed to relieve symptoms. During the first 11 days of life the weight decreased from 3,350 Gm. (7.37 lbs.) to 2,620 Gm. (5.76 lbs.). Physical examination on June 3 was essentially negative except for visible peristaltic waves just below costal margins, traveling from left to right, and incomplete closure of the umbilicus. A small amount of barium administered the same day showed dilatation of the first portion of the duodenum with complete obstruction about the beginning of its second part. Adequate fluid intake had been maintained by administration of subcutaneous saline.

Operation was performed on June 4. A tremendously dilated duodenum presented itself. The transverse colon was small and occupied its normal position. It was reflected from its normal attachment allowing exposure of the retroperitoneal portion of the duodenum which was explored as far as Treitz's ligament. It was seen that a considerable portion of the ascending colon was also retroperitoneal and it was released from its retroperitoneal position. A clear view of the entire small intestine was thus possible and no obstruction was apparent at any point except where the duodenum entered its retroperitoneal position. The retroperitoneal duodenum was small and collapsed but appeared normal. The pancreas appeared normal. There were several small aberrant pancreatic nodules in the wall of the dilated duodenum. Pressure on the dilated duodenum failed to force any gas into the distal retroperitoneal duodenum. The duodenum was opened longitudinally at the point of obstruction exposing a diaphragm about 2 Mm. in thickness apparently completely blocking the lumen of the bowel. Bowel contents were carefully aspirated. A normal bowel lumen was readily demonstrable below the diaphragm. The diaphragm was completely removed by monopolar desiccation, which adequately controlled all hemorrhage. The intestinal lumen was restored by suturing the bowel transversely with silk and reenforcing with mattress sutures of the same material (Fig. 2).

While at no time during recovery was the patient's condition alarming, considerable difficulty was encountered. A 50 cc. transfusion was given following operation and numerous subcutaneous saline infusions during the first four days. Vomiting and distention were troublesome until the twelfth day postoperative. What feedings were retained were supplemented by saline infusions. Gastric lavage was used frequently. It was not until about two weeks after operation that the patient stopped losing weight and began to retain feedings with any regularity. Fluoroscopy showed slight delay in emptying of the stomach but free passage of barium along the upper intestinal tract. All vomiting finally ceased and the patient was discharged July 13, 1932, on the thirty-ninth postoperative day. The weight on discharge was 3,440 Gm. (7.48 lbs.).

The patient was readmitted on two or three occasions during the next few months for coryza, otitis media and on one occasion because of diarrhea and vomiting, neither of which was observed during a subsequent five day stay in the hospital. The general course has been one of constant improvement and normal development. A gastro-intestinal series July 6, 1932, a month after operation, showed some enlargement of the stomach and dilatation of the duodenum but no obstruction to the flow of barium. In December, 1932, at age of six months, she was observed in the hospital for a period of six days. She was admitted because of apparent abdominal pain and constipation. Thorough study showed no evidence of obstruction. In October, 1933, a year and five months after operation, she was readmitted because of intermittent vomiting over a

HIGH OBSTRUCTION IN INFANTS

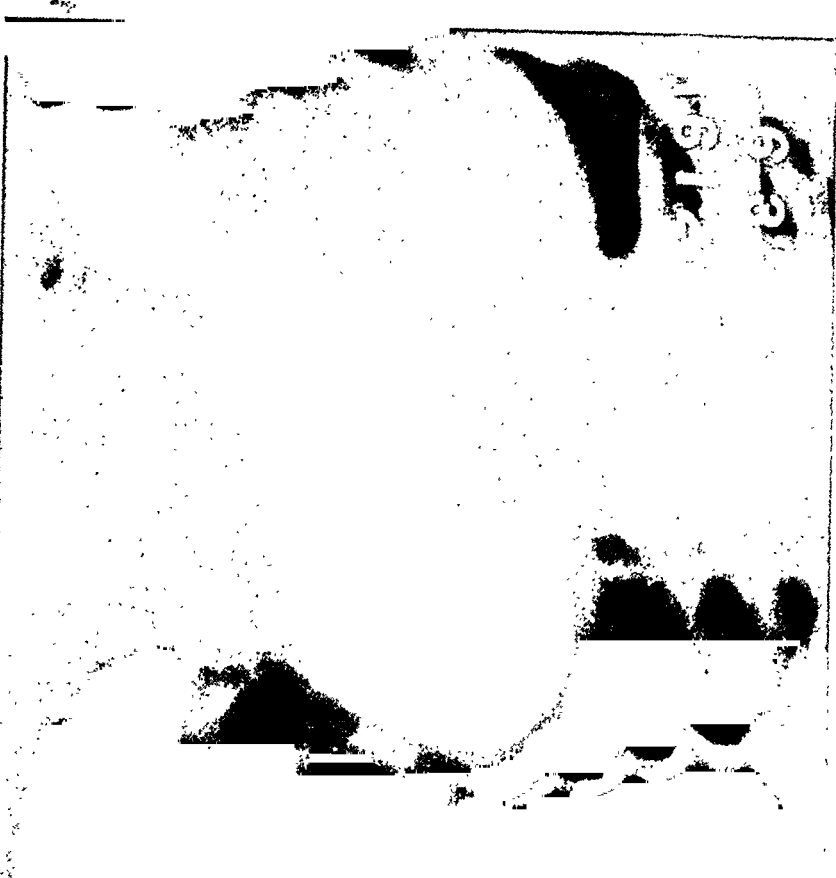


FIG. 2.—Case 2. Dilated atonic stomach and duodenum as shown by roentgenogram.

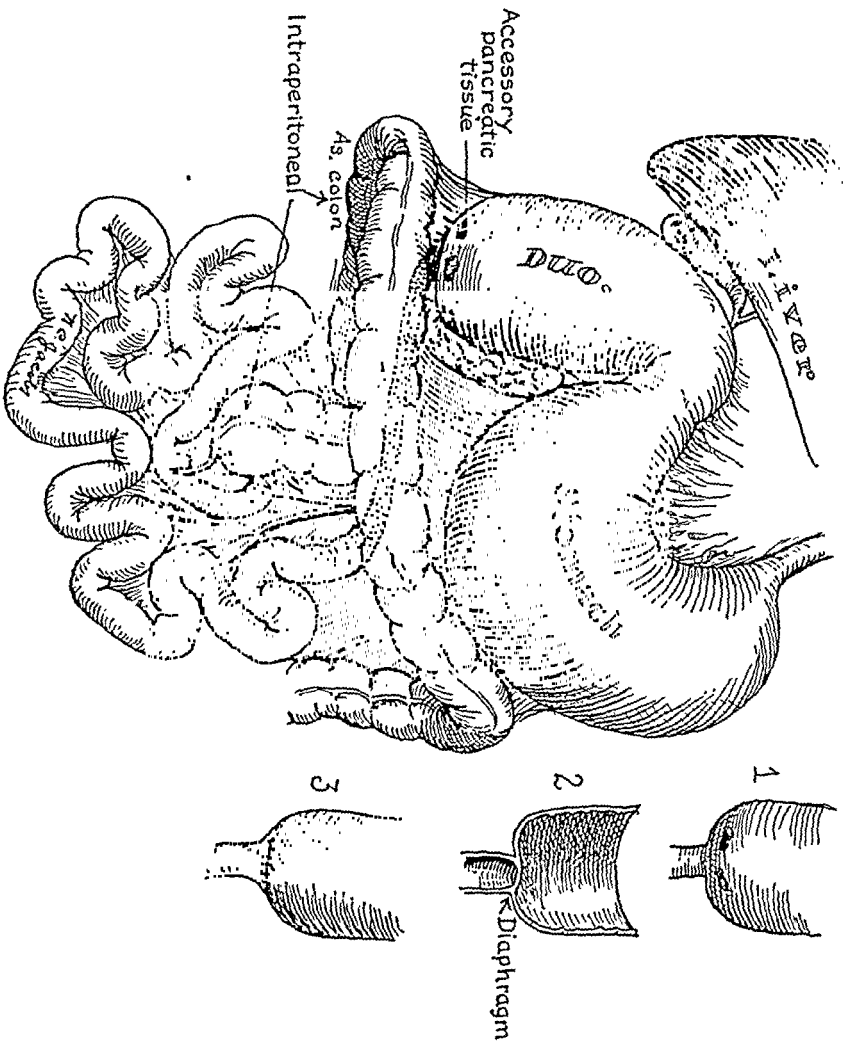


FIG. 2a.—Case 2. Atresia due to diaphragm. Condition found at operation. Repair as carried out to right indicated in Inserts 1, 2, and 3.

period of two months. A gastro-intestinal series at this time showed no definite obstruction. The stomach emptied itself slowly and passage of the barium through the intestinal tract was slow but no point of obstruction was noted. During 1934 there were no gastro-intestinal complaints. Illnesses during 1934 consisted of pyuria on two occasions and whooping cough, otitis media again in 1935, also measles and furunculosis.

Case 3.—No. 35271. E. W., white, male, the third child in the family, age three days, was referred to the Strong Memorial Hospital May 23, 1930, because of persistent vomiting since birth. The antecedent history was entirely negative, both parents being normal adults. The pregnancy and delivery had been uncomplicated. At birth the patient was apparently a normal healthy infant weighing nine pounds. Breast feedings had been started immediately. Vomiting, projectile in type, started immediately after the first feeding and had persisted until the time of admission to the hospital. It occurred regularly about 15 minutes after each feeding and apparently the entire feeding was vomited. The stools, at first greenish in color, became slightly yellow on the third day. There had been a slight discharge from the left eye since birth. On admission to the hospital the patient weighed seven pounds, 14 ounces and physical examination was entirely negative except for a slight conjunctivitis of the left eye. Examination of the blood presented no abnormalities in the cellular elements but the chemical analysis disclosed a non-protein nitrogen of 74 mg. per 100 cc., while the chlorides were 675 mg. per 100 cc. Stool examination was negative. Vomiting persisting despite treatment, a small amount of barium was given by tube the day after admission and its course followed by fluoroscopic examination. The esophagus, stomach and duodenal cap appeared normal except that the latter remained filled and very little if any of the barium progressed into the distal portions of the duodenum. At the end of an hour practically all the barium was still in the stomach, only traces being discernible in the jejunum, which showed vigorous peristalsis. The course of the barium was observed at intervals and at the end of 19 hours no barium remained in the small bowel, about one-quarter being in the ascending colon and the remainder being still in the stomach. It was quite apparent that the infant was suffering from a partial obstruction of the upper gastro-intestinal tract distal to the first portion of the duodenum, the exact cause being undetermined (Fig. 3). With the hope that the underlying cause was such that the obstruction might eventually relieve itself, operative treatment was delayed. During this observation period the infant was given various formulae without any improvement. Dehydration was combated by repeated subcutaneous injection of normal saline, 1,200 cc. administered over a three day period.

Operation was performed May 27 under ether anesthesia. On opening the abdominal cavity through a high right rectus incision, the duodenum, somewhat dilated, was found to occupy a high position. The stomach and pylorus appeared normal. Above the lesser curvature of the stomach in the lesser peritoneal cavity could be seen dilated loops of small bowel. The transverse colon and stomach were reflected upward and Treitz's ligament identified. The jejunum was carefully picked up and an attempt made by gentle traction to deliver it into the wound. There was a slight resistance which on being released, disclosed, in the region of Treitz's ligament, a dilated segment of jejunum which immediately exhibited vigorous peristalsis. At each end of this dilated portion of jejunum there were apparent, across the bowel, definite markings, indicative of constriction. The release of the obstructed segment and its appearance in the wound occurred so rapidly that the opening by which it gained access to the lesser peritoneal cavity was not identified. The intestinal loops had disappeared from the lesser peritoneal cavity and as a rapid examination of the remainder of the gastro-intestinal tract showed no other abnormality, the abdomen was closed.

The postoperative convalescence was entirely satisfactory. There was a moderate amount of vomiting during the first 48 hours during which time an adequate fluid intake was maintained by subcutaneous administration of normal saline solution. The subsequent course in the hospital was uneventful, the infant retaining the prescribed formula

without difficulty. At the time of discharge from the hospital June 3 the infant weighed 3,480 Gm. (7.65 lbs.). About two weeks after discharge there occurred a mild gastrointestinal upset which was readily controlled by a change of formula. On June 25, the patient weighed 4,450 Gm. (9.79 lbs.).

Case 4.—No. 56990. T. C., a white male, age two and one-half months, the sixth child, was admitted to the Strong Memorial Hospital January 29, 1932, because of convulsions. At birth the patient had appeared normal and weighed nine and one-quarter pounds. Projectile vomiting began immediately after birth and still persisted at the time of admission. It occurred usually soon after feeding. At times it would cease for as long as three to four days. Sometimes evening feedings were retained and vomiting would occur in the morning, the vomitus under such circumstances consisting



FIG. 3.—Case 3. The peculiar shadow noted along the lesser curvature is due to a loop of jejunum herniated into the lesser peritoneal cavity. The faint shadow back of the stomach indicates the position of this loop of bowel from its entrance in the para-duodenal fossa.

of the feeding of the previous evening. Occasionally it was yellow or green but generally it consisted of the food taken at previous feeding. The patient was breast fed for two weeks, following which various formulae were tried. Constipation was marked until shortly before admission. Three weeks before admission, while feeding, the patient suddenly became unconscious, remaining so for five to ten minutes. The evening before admission he had the first convulsion, which was repeated several times during the night. Following the first convulsion abdominal distention developed. This was relieved by an enema. There had been slight jaundice for the first two weeks of life.

Physical examination showed a well developed but undernourished male infant, lying with eyes open and eyeballs rolled upward and rotated to the right. The extremities were flexed in a clonic state, but could be extended. Fists were clenched, no cyanosis. While palpating the abdomen, the patient suddenly relaxed and the eyes straightened.

Respirations were irregular. Suddenly the left arm began to jerk, the hand was again clenched and the patient became unconscious. Respirations stopped, the heart beat which had been forceful became distant. Artificial respiration stimulated breathing but respirations continued to be shallow. Convulsions continued throughout the examination. The heart and lungs were normal. The abdomen was moderately distended with the liver edge palpable at the costal margin. The tendon reflexes could not be elicited. There was no clonus. Chostek and Babinski were negative. The temperature was normal.

Laboratory examinations showed: red blood cells, 3,600,000; hemoglobin, 60 per cent; white blood cells, 15,200. The platelets were slightly decreased. The differential was normal. The urine and stool were negative. Blood chemistry showed calcium 9.6 mg., phosphate 5.6 mg., chlorides 410 mg., CO_2 70 vols. per cent. The Wassermann was negative. Lumbar puncture showed a pressure of 15, clear fluid, Pandy negative and one cell.

During the first few days in the hospital the patient's temperature varied from normal to 39.5°C . Vomiting persisted with more or less regularity and was projectile in type. Examination of the vomitus failed to reveal any occult blood. The stools were watery. Five days after admission a left myringotomy yielded a moderate amount of pus. The fluid level was maintained by subcutaneous saline as indicated. Eight days after admission a transfusion was given. On February 16, 1932, a roentgenologic gastrointestinal study showed some pylorospasm, but more important, a marked delay in emptying of the duodenal cap due to some obstruction in the duodenum just beyond the cap. The duodenum was found to be in an abnormal position. All possible variations of formulae and antispasmodics were tried in spite of which vomiting persisted, and even increased in severity and frequency. Despite the patient's poor condition from infection (ears), *etc.*, laparotomy was performed February 26.

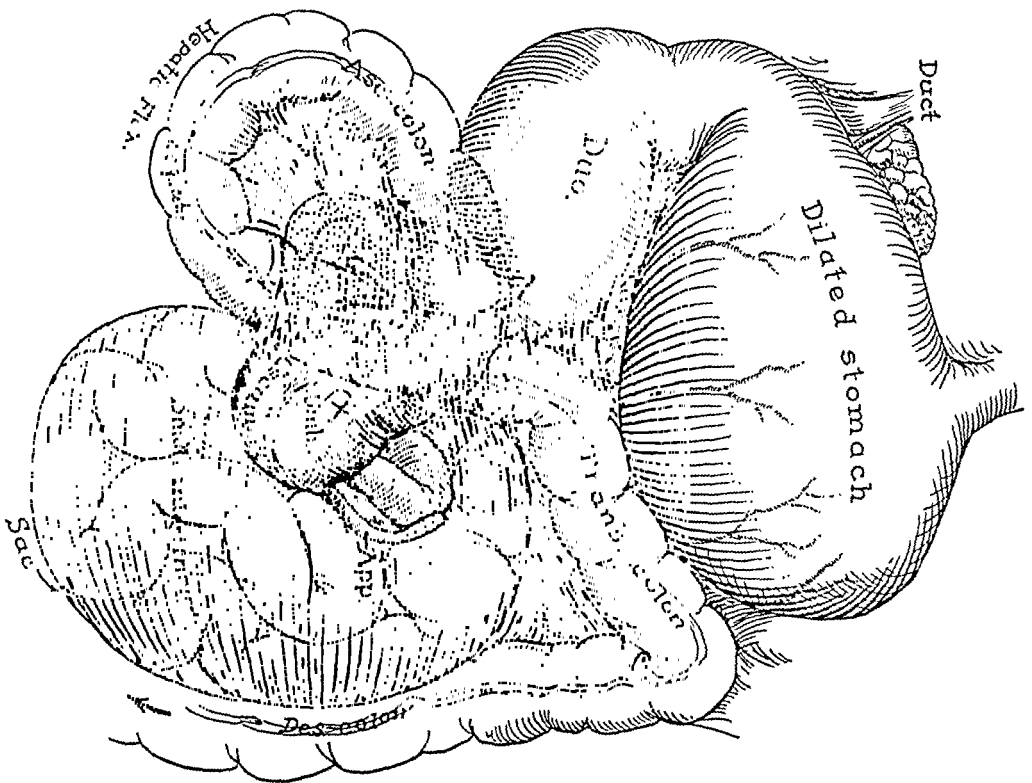
Operation was started under local infiltration which was later supplemented with light ether. The stomach and duodenum were distended. Fine filmy peritoneal bands crossed the duodenum in several places. The omentum was attached to the duodenum. The common duct and pancreas were easily exposed and visualized. The duodenum was dilated to the point where the mesenteric artery and vein crossed. The latter were incorporated in a constricting band. There was no apparent exit of small bowel from this point. Loops of small bowel were visible retroperitoneally in the left side of the abdomen. Involved in the above mentioned constricting band were three loops of large bowel, part of which were adherent to the duodenum in a retroperitoneal position. The cecum and appendix, crossing on top of these loops, were securely fixed by additional bands (Fig. 4). Gentle traction on exposed large and small intestinal loops failed to release this complicated tangle in any way. The lateral attachment of exposed bowel was divided far over on the right side and down to the posterior abdominal wall. It then became apparent that the ascending colon and cecum had looped back around this lateral attachment. The transverse colon had become attached by a peritoneal band in front of the duodenum. By freeing the cecum and appendix it was possible to draw out from its retroperitoneal sac the entire small intestine which was collapsed and dark blue in color from obstruction of its circulation. By careful dissection down to the mesenteric vessels the transverse colon was freed, after which it was possible to untwist the small bowel, thus entirely relieving the obstruction. With the untwisting of the small bowel it immediately flushed to a bright pink color, indicating the release of the obstruction to the blood supply. The small bowel now occupied the entire right side of the abdomen and entered directly into the large bowel, which occupied the entire left side and was not attached in any way to the posterior abdominal wall. The whole gastro-intestinal tract was thus one continuous tube from the pylorus to the sigmoid. The opening in the small mesentery was closed with silk. The operation was surprisingly well tolerated.

The postoperative recovery was entirely satisfactory. Except for some vomiting

FIG. 4.—Case 4. Roentgenogram showing the characteristic dilated stomach and duodenum.



FIG. 4a.—Case 4. The condition found at operation. This is not an internal hernia but a reversed rotation of the midgut on the mesentery. This obstruction is easily handled by exposing the root of the mesentery and twisting the bowel in the reverse direction.



immediately following operation, feedings were well taken and retained. There was a slow steady gain in weight.

Case 5.—No. 107422. J. G., the fifth child in the family, was born prematurely in the Strong Memorial Hospital, September 26, 1935. She weighed 2,480 Gm. (5.45 lbs.) at birth. Vomiting (regurgitation) began on the third day and became projectile in type on the seventh day. It occurred immediately after feeding and consisted of the food previously ingested. Thrush which developed on the sixth day was successfully treated. No bowel movement from October 2 to October 7. An enema on October 7 effected the discharge of some greenish-brown fecal material. There was subsequently a normal stool which was guaiac positive. Changes in formula, antispasmodics, refeeding and gavage failed to control symptoms and the patient continued to lose weight. On October 7, 1935, at the age of 12 days, the weight was 2,300 Gm. (5.0 lbs.). Frequent saline infusions had been given.

Physical examination at this time showed a small, emaciated, premature infant with pinched facies. There was slight cyanosis of lips. The head appeared large in proportion to the size of the body and the anterior fontanelle was soft. There were white membranous patches on the inside of each cheek and on the tongue. The umbilicus was practically healed and there was slight herniation. Otherwise the abdomen was negative.

A gastro-intestinal series made on October 9 showed the stomach and upper intestinal loops filled with gas. The barium left the stomach very slowly.

Operation was performed October 11 under ether anesthesia through an upper right rectus incision. The stomach was large and dilated. The pylorus was normal. The duodenum was dilated and was attached throughout its entire length by peritoneal bands which ran across the duodenum and transverse colon, anchoring it in several kinks making an accordion pleated type of obstruction. The attachment of the transverse and ascending colon was freed to the cecum, after which the large bowel was rotated to the left and the adhesions between the duodenum and mesentery were carefully divided all the way to Treitz's ligament. This allowed the kinked portion of the duodenum to straighten out and assume a normal position. The abdomen was closed with silk.

The postoperative course was satisfactory although somewhat difficult. One transfusion was given postoperatively. Subcutaneous administration of saline and glucose was given repeatedly and regularly during the first five days following operation. Vomiting occurred irregularly during the first ten days, but there was none thereafter. Her general condition improved steadily and at the time of discharge on November 27, aged 62 days, her weight was 3,340 Gm. (7.3 lbs.).

The child was last seen March 2, 1936, aged five months, at which time she was symptom free and weighed 5,840 Gm. (12.8 lbs.), an increase of 3,440 Gm. (7.4 lbs.) since birth.

Case 6.—No. 105930. J. B., a white, female, first child, age 34 days, was admitted to Strong Memorial Hospital September 20, 1935, because of persistent vomiting. Vomiting began about the ninth or tenth day of life and at first occurred only once daily or on alternate days. It always occurred after feedings and was projectile in type. Symptoms increased in severity and frequency up to the time of admission despite all possible variations in formulae and antispasmodics. Refeeding was instituted successfully, the patient never having vomited after this procedure. Shortly before admission peristaltic waves were noted in the epigastrium, passing from left to right. The weight had increased 970 Gm. An interesting point in the family history is that one year before the birth of the patient, the mother had had an exploratory laparotomy, at which time congenital bands causing a partial intestinal obstruction were released.

Physical examination was essentially negative. The only abnormalities noted were areas of capillary hemangiomata over the face and trunk and a somewhat protuberant

abdomen showing peristaltic waves in the epigastrium, coursing from left to right. There was some anemia; red blood cells, 3,160,000; hemoglobin, 11.0 Gm.

Operation was performed September 21, 1935, under ether anesthesia. The stomach and pylorus were normal. The duodenum was dilated two to three times its normal size and was tightly bound down by a series of peritoneal adhesions. These were freed, allowing the duodenum to assume its normal position. The abdomen was closed with silk.

The patient tolerated the operative procedure well. She was given a transfusion and frequent subcutaneous saline infusions following operation. Feedings were given by gavage, the tube being left in place due to the presence of some distension, which soon subsided. There were two normal stools on the second postoperative day. The patient was discharged on the third postoperative day. Her subsequent course has been entirely satisfactory and without symptoms.

Case 7.—No. 97611. N. B., a white male infant, age two days, was admitted to the Strong Memorial Hospital December 21, 1934, for repair of cleft palate and hare lip. Physical examination was negative except for the local condition, *i.e.*, complete left unilateral hare lip and a complete bilateral cleft palate.

The patient vomited every feeding following admission. Stools consisted mostly of meconium with a small amount of formed stool. Changes in formulae and antispasmodics were without avail. Five per cent glucose was given subcutaneously several times each day. Four days after admission, on December 25, a small amount of barium was given. Fluoroscopy showed marked gastric retention with only a minute amount of barium passing through the pylorus. Most of the barium was still present in the stomach after three hours. There was no dilatation of the duodenum. Conservative treatment was continued without any improvement until December 28, when operation was performed.

Operation was started under local infiltration, but it was necessary to change to drop ether in order to adequately explore the abdominal cavity. The stomach, pylorus, and duodenum were normal. The colon was reflected upward and Treitz's ligament identified. Just beyond Treitz's ligament was a marked twisting of the upper jejunum due to hyperperitonealized bands. Salt solution injected into the stomach flowed readily through the pylorus and the duodenum but stopped at Treitz's ligament. The peritoneal bands were divided, releasing the intestinal kinking. There still seemed to be an obstruction at one point. A membrane obstructing the lumen was suspected and the bowel was opened longitudinally. No intrinsic obstruction was found and the opening was closed by suturing transversely. The injected saline then flowed readily beyond this point.

The patient continued to vomit for three days following operation during which time numerous glucose and saline infusions were given. Beginning on the fourth day, feedings were well taken and retained except for an occasional attack of vomiting. Feeding of course was difficult due to the cleft palate. However, the patient's condition improved steadily so that by January 15 the cleft premaxilla was approximated by silver wire under ether anesthesia. The patient expired suddenly at 5 P.M. the day of operation.

Postmortem examination, besides a large frothy bloody mucous mass filling the posterior pharynx, showed focal areas of bronchopneumonia, acute bronchitis, subpleural ecchymoses, and hemangiomata of the tricuspid and mitral valves.

Case 8.—No. 83494. B. C., white, female, age ten months, was first admitted to the Strong Memorial Hospital, December 20, 1933, at the age of four months because of persistent vomiting since birth. The vomiting occurred as often as five to six times per day, three to four hours after feeding, and was not projectile. The vomitus consisted of curdled, partially digested milk, and did not contain bile. The amount varied considerably but for the most part represented only a small amount of the previous feeding taken. Stools had been normal. Physical examination was entirely negative. The blood and urine were normal. Fluoroscopy of the intestinal tract after barium showed a large atonic stomach with marked delay in emptying. She was readmitted



FIG. 5.—Case 8. Roentgenogram showing passage of barium into small intestine, but delay in an egg-shaped loop seen through the gas filled stomach.

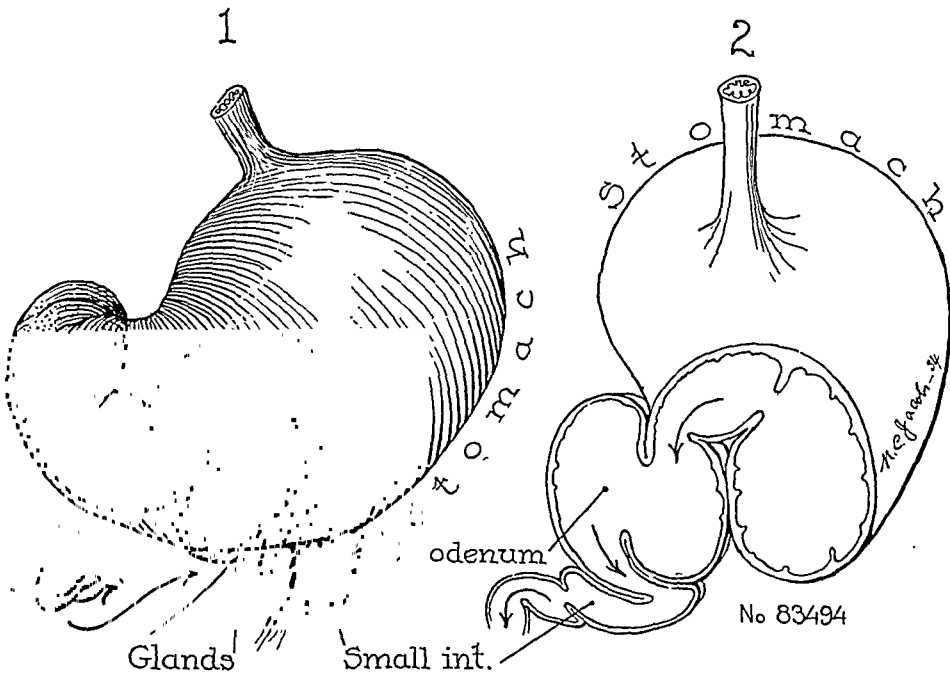


FIG. 5a.—Case 8. The condition found at operation explains the queer egg-shaped shadow in the roentgenogram. This is a torsion and plication obstruction freed by releasing the bands.

for the same symptoms on June 11, 1934, having been carried along on a medical regimen during this time. Vomiting was less frequent. On one occasion peristaltic waves were seen. However, for a week or two prior to admission vomiting increased and the patient lost one pound in one week. In the interim, symptoms had changed somewhat. Vomiting frequently occurred immediately after feeding, and at times was projectile in type. Bile had been present in the vomitus on two occasions. There had been increasing constipation.

Physical examination showed no abnormalities. Abdominal examination was negative. The blood and urine were negative. Examination of the gastro-intestinal tract after the injection of barium showed no dilatation of the stomach but considerable delay in emptying, a fairly large amount being present after six hours (Fig. 5).

Operation was performed June 13, 1934, under ether anesthesia, a right rectus incision being made. The stomach and first portion of the duodenum were dilated. The transverse and ascending colon were freed from the lateral abdominal wall and rotated to the left, giving a good exposure of the retroperitoneal duodenum. In the third portion of the duodenum behind the mesentery there was a longitudinal torsion of the intestine in two places, caused by hyperfixation. The duodenal attachments were freed in these places allowing the duodenum to straighten out. Gas promptly passed into the first portion of the jejunum. The abdomen was accordingly closed (Fig. 5).

The postoperative course was satisfactory though somewhat difficult. Subcutaneous saline infusions were given as indicated. Feeding was resumed the evening of the day of operation. Vomiting occurred at irregular intervals, but never was persistent or alarming. The patient was discharged from the hospital 15 days after operation in excellent condition.

The patient was last seen October 23, 1935, one year and four months after operation. Her condition was excellent and development had been normal. The only vomiting spell noted since the first two weeks after discharge was associated with an acute upper respiratory infection.

Case 9.—No. 89644. R. S., a baby boy, was born in the Strong Memorial Hospital May 21, 1934. He appeared normal. The birth weight was 6.9 lbs. In the first few days of life he vomited mucus on several occasions. Upon nursing at the breast he regurgitated small amounts after each feeding. On the fifth day he vomited once forcefully. The stools were entirely meconium for the first three days and there were no stools for the next two days. The weight dropped till on the fifth day it was 5.4 lbs. He became jaundiced and dehydrated. General examination was negative. The physicians thought that he might have pyloric stenosis and dehydration jaundice. He was given repeated saline infusions. Several different formulae were tried. Atropine 1:1000 was used, one drop before each feeding. In spite of this the vomiting continued and on one occasion it contained a small amount of blood. He was given one teaspoonful of barium in two ounces of his formula and observed under the fluoroscope. The mixture seemed to be delayed at the cardia for some time and was then regurgitated. An esophagoscope was accordingly passed through the cardia and no obstruction was encountered. The pediatricians then placed the child on a thickened formula, each feeding being preceded by gastric lavage. The vomiting seemed to become less in amount for a time. This period of apparent improvement was followed by recurrence of symptoms in a more severe form. It was necessary to give daily infusions. An abscess developed, at the site of one of these infusions, in the left axilla. A second barium study did not give information of value concerning the upper gastro-intestinal tract but small flecks of barium given seven days previously were observed in the rectum, indicating that obstruction was not complete. The child passed small stools containing bile daily. He did not gain in weight but remained at about 6.6 lbs., being supported by daily infusions. No peristaltic waves were observed at any time and no tumor was made out by palpation. A diagnosis of partial obstruction in the duodenum either due to atresia or faulty attachment was suggested by the surgeons. Exploration was carried out June

19, 1934, under drop ether anesthesia. The stomach and the first portion of the duodenum were distended. The pylorus was normal. The right transverse colon was freed from its peritoneal attachments from the midline to the hepatic flexure. Further mobilization was made down to the cecum and the whole right colon was then retracted toward the left, allowing exposure of the root of the mesentery. There were a series of angulations in the retroperitoneal duodenum where peritoneal attachments produced an accordion-pleated effect (Fig. 6). These bands were released and the duodenum traced until it emerged into jejunum under the mesenteric vessels. There were no signs of atresia. Closure was made in layers with silk.

Convalescence was complicated by continuation of vomiting in small amounts, but a gradual improvement was effected by careful regulation of his formula. He was discharged in good condition September 17, 1934, at which time he weighed 9.7 lbs. He was in the hospital in November, 1934, for otitis media. His weight at this time was 11.1 lbs. A bilateral myringotomy was done with relief. On February 28, 1935, he was admitted to the hospital because of a conjunctivitis and an acute purulent left otitis media. He was taking his food without trouble. His weight was recorded as 15.1 lbs. The baby was examined again on April 22, 1936. He was eating and sleeping well. He was regarded as normal. His weight was 22.6 lbs. at this time.

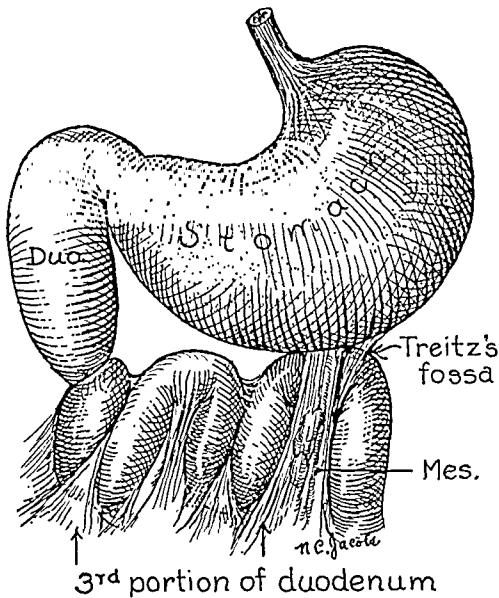


FIG. 6.—Condition found at operation in Case 9. This is an "accordion-pleated" obstruction due to hyperfixation.

feeding. Vomiting was definitely projectile. Constipation was marked, the infant having but one small yellow formed stool per day. The weight on admission was the same as the birth weight, 2,600 Gm.

Physical examination was entirely negative except for undernourishment and a palpable liver and spleen, each of which was 1 cm. below the costal margin. Laboratory examination showed some anemia; red blood cells, 3,700,000; hemoglobin, 80 per cent. The urine was negative. The Wassermann was negative.

All possible conservative measures were tried. The vomiting persisted, and even increased in frequency and amount. On one occasion four days after admission peristaltic waves were seen in the epigastrium passing from left to right. This was noted a second time on September 18. Gastro-intestinal fluoroscopy showed retention, no barium leaving the stomach during an hour and a half of observation. By this time the child's general condition appeared worse than on admission and laparotomy was performed for relief of pyloric obstruction.

Operation.—September 21, under ether anesthesia. A small right rectus incision was made. Because the stomach was dilated, the pyloric muscle was divided although no true tumor was present. Although an adequate explanation of the vomiting was not

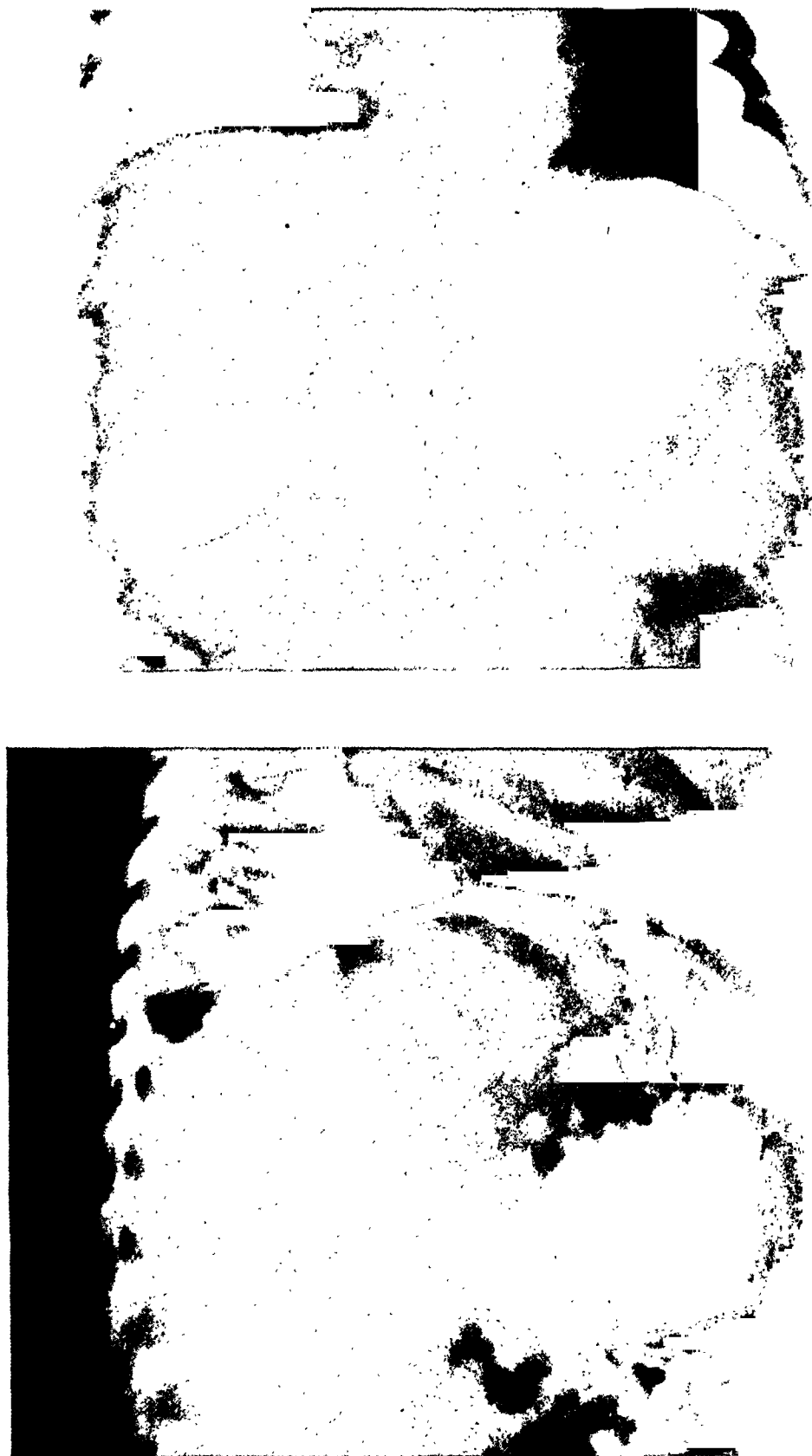
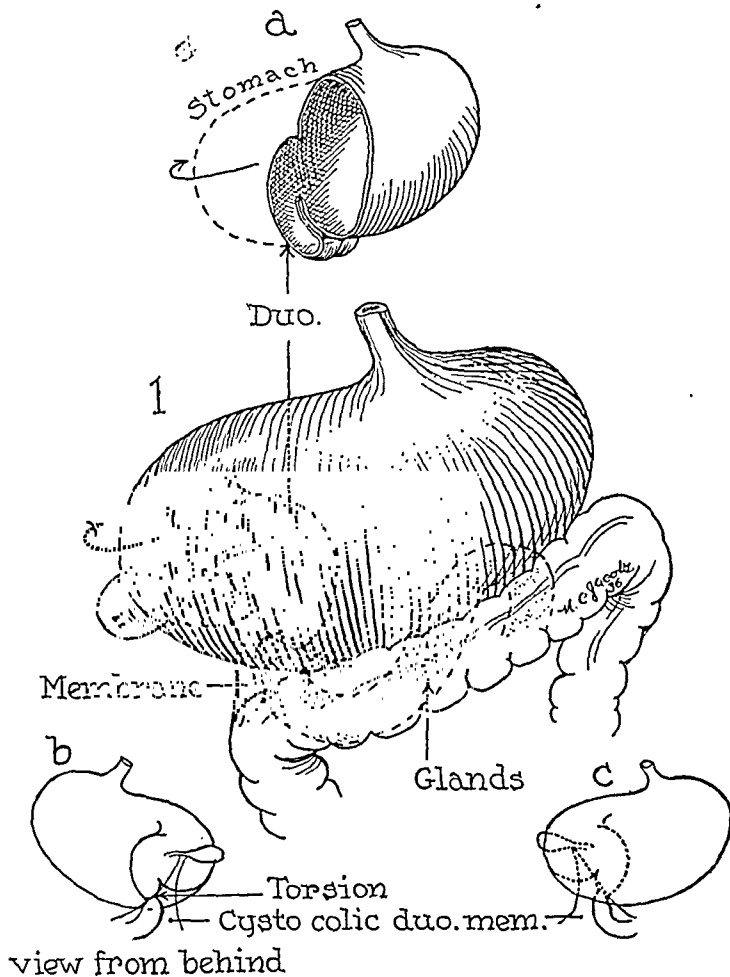


FIG. 7.—Case 11. Anteroposterior and lateral roentgenograms. Showing dilated stomach with folding of antrum and duodenal cap into posterior position. There is a twist of the normal duodenal curve.

demonstrated, the operation was terminated at this point because of the extremely poor condition of the patient.

Following operation the patient was given a transfusion and subcutaneous saline. During the first week after operation the patient's condition improved and vomiting was only occasional. However, beginning on the eighth day vomiting again became regular and frequent and on the following day coffee ground material, which gave a 3+ benzidine reaction, was vomited. A second transfusion was given. The patient vomited blood a second time. Her general condition was poor. The weight on October 3 was 2,550 Gm.



110306 W.B.

FIG. 7a.—Case 11. The condition found at operation explains the roentgenographic appearances. The obstruction in this case was due to a band running from the duodenum to the third part of the duodenum and colon.

A second laparotomy was performed October 4 under ether anesthesia, the previous incision being opened and considerably enlarged. The stomach was dilated. The cecum and appendix were in close approximation to the second portion of the duodenum to which they were attached by peritoneal bands which caused a kinking and obstruction of the duodenum. These bands were divided, releasing the cecum, which was placed in its normal position. A systematic exploration of the entire small bowel showed other peritoneal bands. About four inches from the ileocecal valve other peritoneal bands were found. These involved the ileum and transverse colon in a complicated knot which was released by division of the bands. About six inches proximal a similar condition was found. At Treitz's ligament there was found a triple twist of the bowel,

causing a loop to kink upon itself with an acute angulation when it entered a retro-peritoneal position before emerging into the first portion of the jejunum. This portion of the intestine was intimately associated with the blood supply and consequently it was difficult to straighten it out. After correcting this last abnormality, it was noted that there was a three inch opening in the mesentery of the transverse colon, a congenital defect, as the edges were smooth and regular and contained the blood supply. This rent was carefully closed, following which the intestines were returned to the abdominal cavity and the wound closed.

The patient tolerated the operation extremely well considering her previous poor condition and the unavoidable shock associated with the manipulation. She responded well to an immediate transfusion. There continued to be vomiting but in general it was less frequent and regular and not projectile. The amount vomited was small. Her convalescence was retarded by numerous recurrent upper respiratory infections. In December bilateral otitis media was responsible for a temporary set back. Despite the occasional vomiting, however, the patient showed a general tendency to improve. Her weight increased slowly but steadily, on a moderately thickened formula, and at the time of discharge January 12, 1934, she weighed 4,300 Gm., an increase of 1,700 Gm. over her weight on admission. She was last seen a month after discharge, at which time she weighed 4,660 Gm. During the month she had vomited three or four times.

Case 11.—No. 110306. W. B., a baby girl, was admitted to the Strong Memorial Hospital December 26, 1935, because of vomiting. She was two weeks old at this time. The mother had had an uncomplicated pregnancy and no difficulties at delivery. The child's birth weight was 9 lbs. She was the tenth child in the family. Three of the children before this one had had vomiting, controlled by thickened feedings; one sister had died in infancy from vomiting and diarrhea of two months' duration after many different types of feeding had been tried without success. The present child was fed on the breast for only a few days. A breast pump was then used and the milk fed by bottle. On the tenth day a dilute whole milk formula was substituted for the mother's deficient milk supply. Vomiting was infrequent during the first two weeks. Every feeding was followed in 15 or 20 minutes by a moderate sized well formed stool. Five days before admission the baby became constipated. Stools were obtained only by glycerine suppositories. This child had lost one pound in weight. Examination showed nothing remarkable. She was given a modified formula and sent home. Within the next week she had diarrhea and a marked mastitis was present. She had projectile vomiting on January 7, 1936, and was readmitted January 8.

A suggestion of peristaltic waves in the epigastrium was made out by one observer and confirmed by several others during the next few days. She was placed on thickened feedings. Atropine was tried also but had to be discontinued. The baby continued to vomit and had diarrhea for several days. The symptoms then let up and she gained slightly in weight. She was discharged January 20, 1936. After being home for only a few days, there was a recurrence of symptoms. She regurgitated small amounts after each feeding; had six or more slimy movements a day; cried constantly when awake; and acted very hungry. The mother was reluctant to have her in the hospital but was worn out by the care of the baby during the next ten days. Accordingly the child was readmitted January 31, 1936. Peristaltic waves were easily made out after she had taken a few swallows of water. In a few days all her vomiting and diarrhea had been controlled. Arrangements were made to continue the treatment at home under supervision of a public health nurse. She was discharged February 6. She retained most of her food during the next ten days. And gained weight up to 10.2 lbs. But ten days later she had lost a little because of vomiting, with alternating constipation and diarrhea. A gastro-intestinal barium study was made March 2. She was three months old at this time and had not gained an ounce in the last month. The stomach was greatly distended and atonic. It folded back on itself over the pyloric region so that the antrum and pylorus were pointing toward the left and posteriorly. The duodenum occupied a peculiar twisted position. The

obstruction was partial since only half the barium remained in the stomach after four hours. The diagnosis of faulty fixation of the duodenum on the mesentery with partial obstruction to the stomach was made (Fig. 7).

At operation under drop ether anesthesia March 9 a greatly dilated redundant stomach was found. By gentle traction on the stomach the antrum and pylorus were exposed. The pyloric ring was in spasm which gave the impression of a hypertrophic stenosis, but it soon relaxed. The first portion of the duodenum was slightly larger than normal. On exposing the mesentery by freeing the transverse colon, it was evident that the large bowel had not migrated completely to the right side but was attached just beyond the midline in the region of the gallbladder. The gallbladder was large, and a well defined cystocolic membrane ran across it to the hepatic flexure region of the colon causing a torsion of the descending portion of the duodenum which was caught in this membrane. On freeing it the duodenum straightened out (Fig. 7a). The duodenum was traced all the way to its emergence from under Treitz's ligament without finding any other anomaly. Closure was made in layers with silk. Postoperative course was satisfactory. There was no vomiting. Feedings were resumed rapidly and the patient was discharged March 23, 1936. She weighed 11 lbs. at this time. She has had no symptoms since operation. She takes five to six ounces five times a day and is still not quite satisfied. Her weight at 4½ months, on April 16, 1936, was 12.4 lbs.

Symptoms and Signs.—The most constant symptom presented by every one of these patients is vomiting. It may have been noted a few hours after birth. Usually, however, it is observed only after the first feedings. The vomiting is usually fairly regular. It may occur immediately after a feeding or not till some time within three to four hours. In most cases it begins mildly but progresses to a more violent projectile type as time goes on. Vomiting may be irregular with free intervals of apparent improvement, or it may become steadily more frequent. The vomitus may consist simply in the ingested material, water, milk curds, mucus, or it may contain "coffee ground" material, or blood as noted in Cases 1, 2, and 11. In a doubtful case the presence or absence of bile in the vomitus has been used as evidence of an obstruction above or below the bile papilla. We have not found this examination very valuable; in fact, in this series, chemical or microscopic tests of the vomitus have scarcely ever been recorded.

The presence of blood or "coffee ground material" in the vomitus is considered pathognomonic of duodenal atresia or stenosis. On the other hand, the presence of bile in the vomitus is not a reliable diagnostic sign in localizing the obstruction as it has been demonstrated that enough bile can find its way through the microscopic openings to be readily detectable. Also, as Cordes pointed out, accessory bile ducts may be present entering the intestine above and below the obstruction. The detection of bile in the meconium is likewise subject to misinterpretation for the same reasons and also because of the fact that, while bile secretion begins normally about the third month of gestation, these congenital obstructions may not develop until much later. Consequently, despite a complete obstruction below the ampulla of Vater, the first bowel movements after birth may and often do contain bile which has reached the lower intestine before the establishment of the obstruction.

While normal meconium may be obtained, complete obstipation and absence of milk stools is the rule. If bile is present in appreciable amounts in the vomitus it aids in the differentiation, being absent in pyloric stenosis.

As a sequel to the vomiting there may result an upset in the bowel elimination. The usual trouble is constipation with a tendency towards small dry stools. Occasionally diarrhea has occurred; and alternating periods of constipation and diarrhea. In a number of cases the stool has been normal. Some of these obstructions are only partial in nature so that no absolute rule can be formulated. Blood was recorded in the stool examination in only one instance.

When the vomiting has been persistent, the baby either loses weight rapidly, or he fails to gain under the best of supportive treatment. The weight loss in some instances has been as high as one-quarter of the original birth weight in ten days to two weeks. But it is remarkable that these newborn babies can be carried along for a considerable period, just as adults can be in high obstructions, provided that adequate water and salt are supplied. In some cases where the vomiting has not occurred after every feeding the babies have even shown some slight gain in weight. This is usually a testimonial to the care and skill of the attending pediatrician.

Upon examination the signs of dehydration are frequently observed. These babies appear puny and cyanotic when severely ill. The infants may also show other developmental abnormalities (Cases 1, 6, and 7), or may be prematurely born (Cases 5 and 10). Peristaltic waves passing from left to right have been seen at some stage in examination of these infants in a majority of instances. In Case 1 a tumor was visible occupying a transverse position. When vomiting has been severe there may be signs of alkalosis, manifested by tetany and convulsions.

Course.—The pediatricians attempt to regulate the feedings of these babies by varying their formulae; substituting different materials; changing the frequency or consistency of the feedings; feeding by tube; expressing air from the gastro-intestinal tract and refeeding; and the use of antispasmodics. In some instances the babies are found to be habitual air swallowers and regurgitators and must be broken of the habit. Rarely, there also seems to be a protein sensitiveness to milk in some infants. Fluids and salts can be supplied parenterally as necessary when the vomiting is not controllable by other means. Transfusions may be of value. We cannot praise too highly the skill and resourcefulness of our pediatric staff in the management of these infants. When, in spite of all efforts, vomiting continues, an attempt to localize the lesion accurately by roentgenologic examination seems warranted.

Roentgenologic Examination.—Although it is admitted that a barium mixture should not be used above an obstruction, we have made use of a thin mixture of barium in most of these cases. The information which it gives us in this group seems to outweigh its disadvantages as we have decided to operate usually in any case because of the persistence of symptoms. The

barium can be evacuated by lavage or by vomiting when operation has to be delayed for any reason. In Cases 1, 2, and 4 characteristic dilated atonic stomach and duodenum shadows indicated that the obstruction was near the third portion of the duodenum (Figs. 1, 2, and 4). In Case 3 a peculiar sausage shaped shadow along the lesser curvature attracted our attention. This child was thought to have hypertrophic pyloric stenosis until the roentgenogram helped us visualize the true lesion. The parallel shadows of this herniated loop can be seen through the gastric shadow on this one film of the series (Fig. 3). Roentgenograms in Cases 5, 7, and 9 showed delay in gastric emptying but gave no other help in the diagnosis. In Case 8 the dilated duodenum showed retention and a clear rounded outline after the barium had left the stomach. It clearly indicated that the partial obstruction was in the duodenum behind the stomach (Fig. 5). In Case 11, by use of the lateral view, it was possible to recognize that the greatly dilated stomach had folded back upon the pyloric antrum; and that there was a peculiar angulation in the duodenal loop leading away from this region (Fig. 7). We think that this information together with the fact that it sometimes shows that obstruction is not complete is of value to us. We have never yet seen any deleterious effects from the use of this method.

Differential Diagnosis.—The only real problem in diagnosis is to differentiate these cases from those of congenital hypertrophic pyloric stenoses. Congenital hypertrophic pyloric stenosis usually occurs in males and usually in the first born child in the family. The onset of vomiting is rarely at birth. It usually appears some time during the second to the sixth week. In a majority of cases the vomiting increases in severity, becoming projectile in character. Peristaltic waves passing from left to right can be made out in about three-quarters of the cases. A palpable tumor can be felt with varying success, this depending to some extent upon the importance attached to it by the examiner. The other symptoms and signs—loss of weight, dehydration, alkalosis, constipation and scanty urine are common to the two conditions. A study of congenital hypertrophic pyloric stenosis in our clinic showed that it occurred in males in 90 per cent; that it had been noted in the second child in the family once; in the third child twice; and once in the sixth child of the family; that vomiting started at birth in one instance; and that it did not start till two months of age in another; the rest of the cases following the rule; that peristaltic waves were observed in 80 per cent; and that a palpable pyloric tumor was made out in just half of the cases. In our cases of congenital obstruction there were seven females to four males. The majority also were not the first born in the family. There was one first born girl and three other possible first born babies though this point was not stated in the history. The others ranged from the third to the tenth child in the family. The vomiting came on early—usually before the first week, sometimes during the first day, and often following the first ingestion of anything. Two of the children were prematurely born; and three showed other congenital abnormalities. Peristaltic waves were made out in

seven of the 11 cases but no tumor was palpated in any of them. The roentgenogram had diagnostic value in six of the 11 cases. It would appear from this review that we should look with suspicion upon any baby which starts vomiting during the first week of life, especially if of the female sex and with other signs of congenital anomalies. If no relief can be obtained by medical measures we should be prepared to give a thin barium mixture for roentgenologic appraisal of the cause. The presence of peristaltic waves with the absence of a palpable tumor might be regarded as of some significance in helping to make the diagnosis. The presence of bile or blood in the vomitus would be in favor of some lesion other than hypertrophic pyloric stenosis.

Intussusception can be ruled out by its usual onset still later in life than that of hypertrophic stenosis; and by the typical acute picture it presents.

Strangulated inguinal hernia must sometimes be differentiated but in our experience this has not been difficult.

Prognosis.—Intestinal obstruction in the new born due to congenital abnormalities is not uncommon. The fact that a large percentage of such cases reported in medical literature is based on postmortem examination is evidence of the extremely high mortality associated with this condition. A universal appreciation of the comparative frequency of its occurrence will tend to improve results as the unfavorable outcome in many instances is directly attributable to incorrect diagnoses or to diagnoses established too late for surgical intervention to be successful.

In a certain percentage of cases of intestinal atresia (15 per cent according to Davis and Poynter), the congenital defects are multiple and beyond the aid of surgery. Furthermore, many of the defects occur in the duodenum and upper jejunum (194 of the 392 cases in the series of Davis and Poynter), thus placing them in the category of high intestinal obstructions. This, superimposed upon the fact that the new-born infant is not a good operative risk, mitigates against improvement in results in such cases. Admitting a necessarily high mortality upon the basis of these facts, there still remains a definite percentage of fatal results which can, conceivably, be eliminated by early correct diagnosis and the prompt institution of surgical treatment. An organic mechanical obstruction demands early operation for its relief. Since many of these congenital defects are amenable to operative treatment and this fact can be established only at the time of operation, all cases so diagnosed should be given the opportunity of relief which only operation affords.

The prognosis in cases of congenital occlusion of the small intestine is extremely poor. The first successfully treated case is credited to Ernst¹⁴ who operated upon an infant ten days old for congenital duodenal atresia, relieving the condition by a "duodeno-entero-anterior anastomosis." Eleven months postoperatively the patient was progressing normally. In 349 published articles there are reports of 29 cured cases: 15, in which the obstruction was due to malrotation, and 14, in which the obstruction was intrinsic,

atresia or stenosis.⁵ In the 60 cases reported by Ladd the mortality was 70 per cent. The mortality in cases of malrotation was 55 per cent (nine cured of a total of 20 cases) and in cases of intrinsic obstruction it was 80 per cent (eight cured of a total of 40 cases). These results showed a great improvement when one considers the statement of Thorndike¹³ who placed the mortality of congenital duodenal atresia at 99 per cent. In the present group of 11 cases there has been only one death, a mortality of 9 per cent.

The prognosis in cases of congenital anomalies about the mesentery depends to a large extent upon the alertness of the attending physician. These babies can stand a considerable amount of fluid and salt loss if it is compensated for by parenteral medication. It is also true that in some cases the obstructions are only partial so that the baby gets some nourishment. When the child loses weight or fails to gain because of the amounts lost by vomiting, steps should be taken to correct the underlying fault if possible. The surgeon also must bear his share in getting these babies by the operation. This requires gentle handling of tissues more than any other single thing. The fate of these babies depends then upon the preoperative condition—a reflection of the care given by the attending physician; the operative manipulation and judgment—a reflection on the care of the attending surgeon; and the continued combined efforts of both physician and surgeon in the post-operative follow up. In our series the results have been excellent. All the babies have been carried through the operation to relieve their obstructions without a fatality. There have been two deaths, one almost two years after the operation, from pneumonia; the other as the result of a second operation for cleft palate two weeks after the duodenal obstruction had been relieved satisfactorily. This baby was a great feeding problem which forced action against better judgment. The postmortem examination showed bronchopneumonia which may well have been due to aspirated food.

Treatment.—Preliminary preparation for operation is exceedingly important. Loss of weight and dehydration must be combated by restoring the water balance. This may be done by the intravenous, intraperitoneal or subcutaneous routes. Blood, water, glucose and salt may be used as circumstances require. We usually fluoroscope these infants to see whether an enlarged thymus is present. If so, operation would be delayed for a few days following roentgen therapy. Usually no preoperative drugs are necessary. Occasionally atropine in 1/400 to 1/200 gr. doses is given. We have used local infiltration in the past but when there has been crying, straining and evisceration of the bowels, so much damage has been done in restoring the viscera to the peritoneal cavity that we have abandoned this practice. Drop ether carefully given by a well trained anesthetist, we believe to be the anesthetic of choice. A very small quantity will often suffice. Most writers agree that babies do not stand hemorrhage, shock or infection well.^{10, 20, 21} For these reasons during operation there must be most careful hemostasis; gentleness in handling tissues; lack of exposure to prevent heat loss; and progression without delay so that a minimum of anesthesia is necessary.

Emphasis should not be placed on speed in these operations. Babies will stand operations well for one and one-half hours or longer if necessary. However, the more time that a surgeon can save, without sacrificing gentleness, the better. Respect for the tissues is by far the most important factor in these operations. The flashy, speedy, rough surgeon will not do well with these patients. Abdominal closure is made in layers with fine silk. We have had no disruption of these wounds and no infection. The dressing is made light and sealed in with waterproof adhesive.

In congenital absence of a segment of duodenum, obviously the relief of the obstruction by operation is the only treatment possible. A short circuiting operation, duodenojejunostomy or gastro-enterostomy, is the logical procedure. The choice between these two procedures will vary with the operator and the conditions encountered in the individual case. In those cases in which there is a diaphragm stretched across the lumen of the bowel,

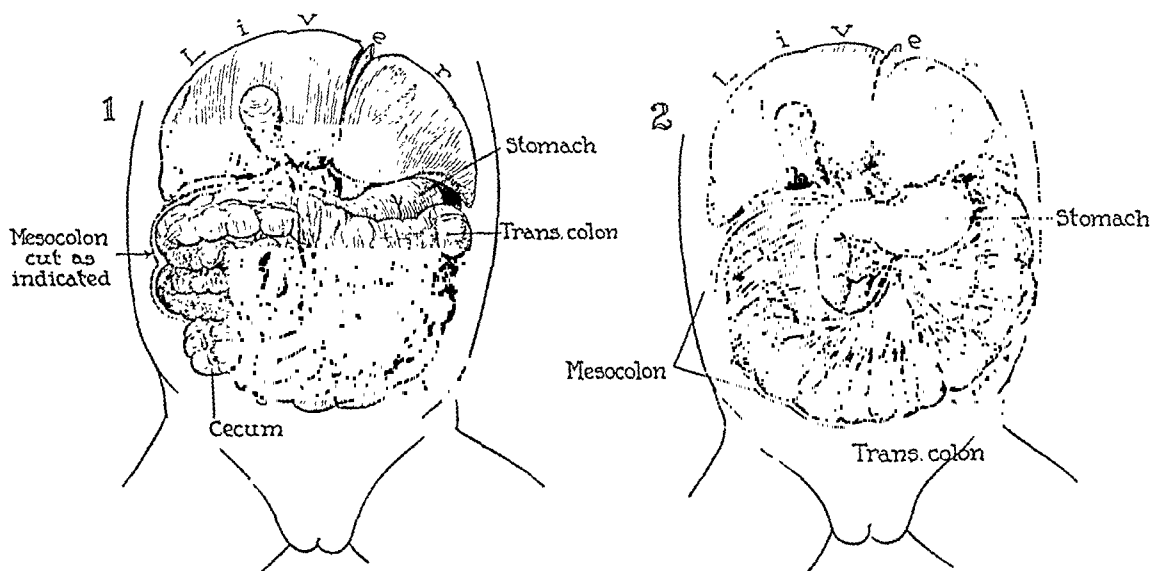


FIG. 8 (1 and 2).—Represents the operative approach to the root of the mesentery. The transverse and ascending colons are freed from their lateral attachments and the retroperitoneal duodenum exposed. The condition illustrated in 2 was present to some degree in Cases 5, 6, 7, and 10.

longitudinal incision of the intestine, removing the diaphragm and transverse suturing, as proposed by Morton¹⁵ and performed by Petersen,¹⁶ should be seriously considered as being a simpler procedure than intestinal anastomosis. However, it is often difficult to definitely establish the presence of such a diaphragm. Under no circumstances should an enterostomy (jejunostomy) be performed, as it is only a palliative procedure which is not well tolerated by infants. In those cases in which it has been done a rapid death resulted. Clogg¹⁷ has made a valuable suggestion that, in as much as congenital intestinal defects are prone to be multiple, one should inject fluid into the collapsed bowel below the obstruction, forcing it along to discover the presence of any additional defects. This possibility should always be kept in mind, as it might easily condemn to failure what otherwise would be an entirely successful operation.

The operation of choice for the extrinsic anomalies due to faults in migration, descent, and fixation, is not to attempt a gastro-enterostomy or

entero-enterostomy as has been done so often in the past. The surgeon should realize that this is the type of obstruction which can be successfully untangled if he knows how to get at it. The best way to unravel these puzzling anomalies is to get a clear view of the mesentery. This can be done only by detaching the transverse and ascending colons from the parietal wall and rotating them toward the midline, which gives excellent access to the root of the mesentery (Fig. 8). This operation we had worked out independently in our clinic only to find that Ladd had been using the identical procedure. We believe that this operation will result in a decided improvement in the operative mortality in these extrinsic anomalies. It stands in much the same relationship as the division of the pyloric sphincter did to cases of pyloric stenosis with the consequent abandonment of the previous posterior gastro-enterostomy operations.

The surgeon should not enter the abdominal cavity with a preconceived idea that he is going to undertake a certain procedure. It is most difficult to abandon the plan to fit circumstances which may not demand it. It is especially difficult not to wish to simply divide the pyloric muscle in some of these cases.

After operation special nursing care is of great importance. The baby must be kept warm, but not so hot that he will lose his fluids through perspiration. Cold draughts must be avoided. Fluids should be restored again. Codein may be used for pain. Distention should be combated with stupes, rectal tubes and later enemata. Babies do not stand pain and distention well. Their reactions to these are violent and alarming. Lavage may also be necessary. Acidosis may be prevented by the use of glucose. The baby should be restored to his normal environment as rapidly as his condition warrants. His dressings must be kept dry, especially during the first week. Measures should be taken to seal off the urinary tract from the operative site by suitable apparatus. It is a pleasure to acknowledge the close cooperation of Dr. Samuel Clausen and his staff in the after care of these patients.

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SPLENECTOMY FOR HEMOCLASTIC CRISES*

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DURING the clinical course of certain blood diseases, namely, congenital hemolytic icterus and thrombopenic purpura, there occur episodes of increased blood destruction. These are known clinically as "crises." They may develop spontaneously or be precipitated by various environmental factors. In congenital hemolytic icterus the increased destruction affects chiefly the erythrocytes. In thrombopenic purpura there may be an increased destruction of thrombocytes. Although splenectomy is ordinarily the treatment of choice in the more chronic stages of these hemoclastic dyscrasias, it has been thought,^{7, 9, 11, 12, 13} and it is the accepted surgical teaching^{4, 5, 6, 8, 10} at the present time, that the acute exacerbations are a direct contra-indication to splenectomy.

Previous studies within our group^{1, 13, 14} have provided evidence which incriminates the spleen as one of the principal factors in the physiologic control as well as in the pathologic destruction of the circulating blood elements. If such be the case, then, during exacerbations of splenic activity, even to the extent of "crisis" proportions, removal of the spleen is not only desirable, but in many instances may become essential to survival. Nevertheless, the risk involved in undertaking any major abdominal operation with a total red count rapidly approaching the one million mark, has, heretofore, interdicted splenectomy under such circumstances.

In addition to the conviction that the major rôle was played by the spleen in the diseases under discussion, our early studies revealed, as a part of the postsplenectomy mechanism, an immediate marked postoperative rise in both the red blood cells and platelets, which amounted essentially to an auto-transfusion. The specificity and significance of this response have been discussed¹ and form the basis for our having undertaken a series of splenectomies during active hemoclastic crises without as yet encountering one operative fatality.

It is the purpose of this paper to present the pertinent clinical evidence from eight patients each successfully splenectomized during an acute hemoclastic crisis. Six of the patients had congenital hemolytic icterus; two had thrombopenic purpura.

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CASE REPORTS

CONGENITAL HEMOLYTIC ICTERUS

Case 1.—H. S., a mail carrier, age 50, was admitted to the Research Service of the University Hospital, December 4, 1933, presenting splenomegaly, severe epigastric pain and deep jaundice.

As a boy he had noted his sallow skin. He was advised also of an anemia, and was aware that he fatigued easily. About 20 years ago he was diagnosed as having "splenic anemia." He had already noted the mass in his upper left quadrant. He was hospitalized, about 19 years ago, for what appears to have been a subacute exacerbation. Splenectomy was advised at that time but was not accepted. Since then, he has presented the characteristic picture of chronic congenital hemolytic icterus. During the past three years the disease has gradually become more severe, and in addition, mild symptoms of cholelithiasis have appeared.

On November 29, 1933, while delivering mail, he experienced acute, severe epigastric pain, which disabled him. Jaundice became evident the next day, and grew progressively deeper. His food intake was decreased and an unusual weight loss ensued. An associated acute hemoclastic crisis was suspected, and he was referred to the Research Service by Dr. Paul A. Adams.

His past history reveals mainly the story of congenital hemolytic jaundice with the characteristic ebb and flow of its minor symptomatology. During the past few years his appetite has diminished and an associated weight loss has ensued. To his knowledge none of his family except his son has had evident icterus. This son, an icteric, frail boy of 15, with marked splenomegaly, was subsequently (July 12, 1934) successfully splenectomized on the Research Service for this same disease.

Physical examination of the patient revealed marked weakness, enlarged spleen, anemia and a deep jaundice. T., 98.2°; P., 66; R., 15; B. P., 140/70. The sclerae were deep yellow. The spleen extended 4 cm. below the umbilicus. The liver was enlarged and tender. There was definite right epigastric tenderness. The urine was negative, other than for the high bile content. The stool was not acholic and was negative for blood. Roentgenologic examination revealed a small annular shadow, about 1 cm. in diameter to the right of the upper body of the third lumbar vertebra. The gallbladder was not visualized.

The significant blood findings are presented in Chart 1. There was no significant anemia (red blood cells, 3,820,000; the reticulocytes were 4 to 6 per cent); a microcytosis (mean red blood cell diameter 6.9, mean red blood cell volume 100 cu. microns), and an increased fragility of the red blood cells (0.582 to 0.300) were found. The icterus index was 882, the highest we have ever recorded. The patient was Type B blood group. On December 5, the direct van den Bergh was immediately positive, and the indirect was 21 mg. During the 48 hours subsequent to admission the red count fell to 3,000,000 and the reticulocytes gradually increased to 14.2 per cent. The icterus index decreased appreciably, to 428 (Chart 1).

The findings thus indicated an icterus of double origin; an older, congenital hemolytic form with splenomegaly, and a more recent acute, acquired form due to obstruction by a common duct stone. Since about two-thirds of patients with hemolytic icterus develop pigment calculi within the gallbladder, such an occurrence is readily understandable and should be anticipated. There was evidence of only moderate hemolysis. The preoperative icterus index was 440, predominantly of obstructive origin.

Two courses of management were considered: (1) Splenectomy, to stop an impending hemoclastic crisis, and (2) a preliminary cholecystostomy, in an attempt to relieve the acute and severe cholemia. The latter seemed the more threatening. It was clearly realized, however, that the cholecystostomy might provoke even more severe hemolytic activity by the greatly enlarged spleen.

The relatively good level of the red cells and hemoglobin (Chart 1), together with

the evidence of but moderate hemolysis, influenced us to follow the second course in the hope that the obstructive jaundice might subside somewhat before the onset of a more acute hemolysis. The patient was prepared for cholecystostomy by the administration of 5 cc. of 10 per cent calcium chloride in 200 cc. of normal saline intravenously, and by a hypodermoclysis of 1,500 cc. of Ringer's solution containing 5 per cent glucose. This was given the evening before, and repeated the morning of the laparotomy.

Cholecystostomy was accomplished uneventfully on December 7, under local anesthesia, using a nitrous oxide-oxygen supplement. The abdomen contained considerable bile-stained ascitic fluid. The liver was greatly enlarged. It was greenish, finely nodular and the lobules were unusually prominent. The gallbladder was enlarged, and its walls were thickened and injected. It compressed readily, and contained numerous stones. The cystic duct was about 7 Mm. in diameter when flattened. It appeared to be patent. The common duct was tense and distended. At its lower portion, well above the ampulla, was a hard, irregular mass about 15 x 10 x 10 Mm. This was thought to be a stone, although it was not explored with a needle. The spleen was huge and moderately adherent. The splenic capsule was thick, white and opaque. The adhesions were soft and vascular.

Opening the gallbladder fundus revealed the thick, fibrous wall, a rather normal yellow-brown bile and numerous characteristic pigment stones, which varied up to 18 Mm. in diameter. They were black, somewhat elastic, friable and most irregular in shape. They were removed and the cystic duct explored. It was patent. The gallbladder was drained. Careful hemostasis was effected, and there was but a moderate loss of blood. The patient was returned to his room in good condition with the blood pressure 78/44.

Progressive relief from the cholemia ensued. The icterus index, 24 hours postoperative, fell to 120 (Chart 1). On the other hand, hemolysis definitely increased. On the evening of December 9, 36 hours postoperative, the red count had fallen to 1,610,000 and the hemoglobin to 3.9 Gm. The reticulocytes had risen to 20 per cent. An acute, even fatal, hemoclastic crisis threatened.

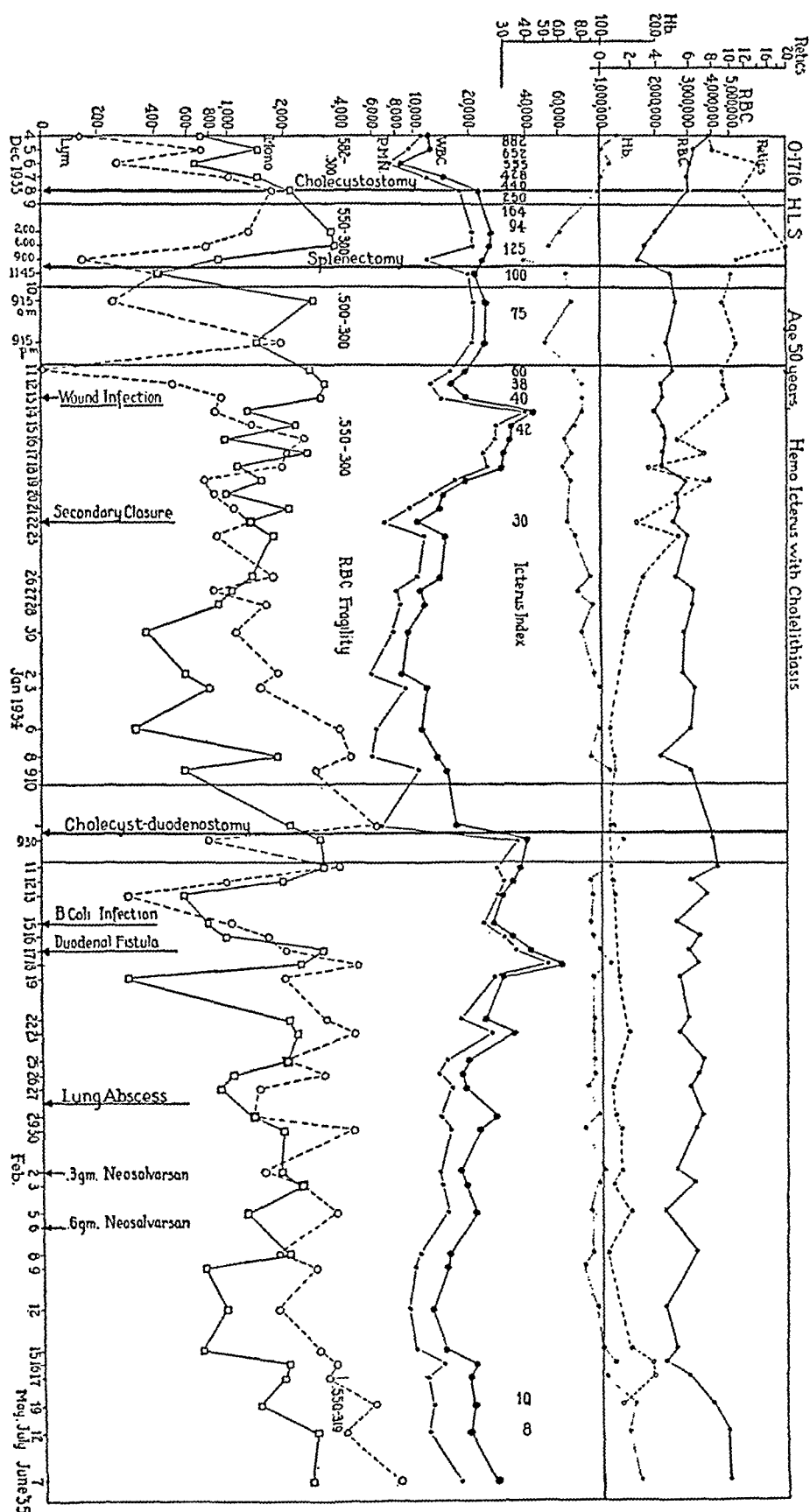
From our previous experience it seemed evident that splenectomy was indicated as being the most reasonable procedure to arrest the unusually severe, although expected complication. We could also, with reasonable assurance, depend upon the customary postoperative autotransfusion as a restorative measure. An emergency splenectomy was performed, therefore, December 9. The patient was prepared for this as for the cholecystostomy. Local anesthesia, supplemented by nitrous oxide-oxygen, was employed. Adrenalin, 1 cc., was administered intramuscularly about 20 minutes before clamping the splenic pedicle. This was to ensure maximum contraction of the smooth muscle in the splenic capsule and trabeculae.

The spleen was removed without incident through a left subcostal Kocher incision. During the procedure the blood pressure, increased by adrenalin, remained elevated around 140/50. There was no evidence of circulatory failure and prompt postanesthetic recovery ensued.

The spleen weighed 1,740 Gm., and measured 22 x 15 x 9 cm. It was firm, and apparently contracted. The capsule was in places as thick as 4 Mm. and an opaque white. The splenic pulp was increased. It was dark red, cellular, friable and more fibrous than normal. Microscopically the splenic corpuscles were infrequent, and the pulp spaces were filled with blood. The phagocytic clasmotocytes were increased.

Immediately following operation the characteristic and expected autotransfusion ensued, and the reticulocytes decreased (Chart 1). The icterus index continued to decrease, and reached 30 on December 14. Convalescence was then uneventful until December 13, when the patient became disoriented, arose and walked about the room. A chill followed, and later a fever and leukocytosis (Chart 1). Vomiting supervened. There was no bile in the vomitus. *B. coli* infection of the splenectomy wound was apparent December 15. It was drained and treated by dakinization. The skin flaps separated and on December 22 a secondary closure was undertaken under local anesthesia.

CHART 1.—(Case 1) Splenectomy for the hemoclastic (erythroclastic) crisis of congenital hemolytic jaundice. (Journal A.M.A.)



Dakinization was continued and sound healing, without subsequent herniation, eventually occurred.

Biliary drainage continued; however, there was no evidence of autodigestion about the cholecystostomy opening. The original rubber tube was later replaced by a mushroom catheter which minimized the leakage. Convalescence was steady and afebrile.

On December 27 the biliary tract was visualized by injecting lipiodol through a small catheter inserted into the cholecystostomy opening. The gallbladder, also the cystic, hepatic and common ducts were examined fluoroscopically. The lipiodol came to an abrupt stop, 6 cm. down the dilated common duct. Roentgenograms revealed an irregular block in the region of the shadow which was inferred to represent the common duct stone. There was a questionable leak past the stone into the intestine. A subcutaneous tract was also demonstrated connecting the cholecystostomy margin with the infected splenectomy wound. This was possibly the original avenue of infection. No reaction followed this investigation.

The bile draining from the cholecystostomy showed no evidences of containing pancreatic secretion, which apparently entered the duodenum normally as shown by aspiration through a duodenal tube. Thus an irregular, occluding common duct stone remained, definitely above the ampulla of Vater and which did not obstruct the external pancreatic secretion. The increased risk of removing this stone, by mobilizing the duodenum medially, performing a choledochotomy, and of possibly inserting a T tube, was weighed. To be sure, the cholecystostomy assured temporary biliary drainage. Eventually, however, owing to the continued fluid and mineral loss, it required closure. Cholecystoduodenostomy was finally elected as the best solution of the problem. This was accomplished January 10 under local anesthesia, using supplementary nitrous oxide-oxygen.

The cholecystostomy opening was dissected free, the gallbladder fundus mobilized, and the stoma trimmed. The gallbladder fundus was then attached to the adjacent duodenum and a two row cholecystoduodenostomy accomplished. The suture line was then fastened to the fascia of the gallbladder bed with interrupted silk sutures. A Penrose drain was left just under the skin. Ephedrin was given at the end of the operation. The blood pressure was 88/66. The pulse was fair, rate 112. There were no evidences of shock.

During the ensuing two days the temperature rose to 104.8°; pulse, to 160; and increased respirations. These all gradually subsided. On January 14 the patient expectorated a foul smelling, thick, tenacious mucus. On January 15 a *B. coli* infection of the right abdominal wound was noted. This broke down and on January 17 a duodenal fistula became established. Bile and duodenal juice were identified. The skin edges became eroded. The duodenal fistula was treated by plugging, strapping, care of the skin edges and the use of a light cradle. It soon began to fill in and was closed by February 6.

On January 19, cough and considerable foul smelling sputum production were noted. This continued. A roentgenologic examination January 26 revealed a left hilus shadow suspicious of lung abscess. This was confirmed by a stereoscopic examination January 31. A fluid level was evident. The abscess wall was thin. Adequate postural drainage was instituted. Because of the character of the sputum on February 2 and again on February 6, neoarsphenamine was administered. The sputum production began to decrease February 4. It was only 10 cc. in amount by February 10, and ceased on February 12. Stereoscopic examination, February 16, showed no evidences of any residual lung abscess, and a clear parenchyma. General improvement ensued. The patient's appetite returned, and he gained weight. The patient was discharged February 17.

At no time during this stormy convalescence, subsequent to the splenectomy, was the hemolytropic equilibrium seriously disturbed. The bone marrow met all demands promptly and efficiently as they arose (Chart 1). There were no evidences of decompensation or incapacity. This is of significance in evaluating the fundamental nature of congenital hemolytic icterus.

Since leaving the hospital the patient has gained 40 pounds (18 Kg.). Both

operative wounds are well healed without herniation. There have been thus far no evident gastro-intestinal symptoms referable to the results of the extensive abdominal surgery. The patient resumed his occupation as mail carrier, June 1, 1934. July 12, 1934, the day splenectomy was successfully accomplished on his son, the father's red blood cells were 4,850,000, hemoglobin 14.2 Gm., color index 0.95, reticulocytes 1.2 per cent, icterus index 8, hematocrit 52, erythrocyte fragility 0.550-0.319 and leukocytes 19,000, with an essentially normal differential percentage. After two and one-half years the patient continues to remain clinically well.

Case 2.—B. Y., a housewife, aged 56, was admitted to the University Hospital February 9, 1935, presenting great weakness, an unusual pallor, moderate jaundice and an enlarged spleen.

Since childhood she had noted that she very easily became fatigued, that even minor ailments disabled her greatly, and that she had a peculiar pallor. At one time she was thought to have pernicious anemia. Four months ago she developed an upper respiratory infection. This resulted in an increase in the anemia and the development of recognizable jaundice. During the succeeding interval there have been remissions and relapses with, however, a progressive increase in weakness and pallor. One son of 28 has had manifest jaundice during the past year. There is evidence of generalized arteriosclerosis. A cerebral vascular accident two years ago resulted in a residual hemifacial paralysis with ptosis of the eyelid and some atrophy of the right side of the tongue.

Physical examination revealed a striking exhaustion. She was poorly oriented. The loose, pale skin indicated considerable weight loss. Pitting edema was noted over the tibiae and sacrum. The retinal arteries were tortuous and striped. Hearing was diminished, particularly on the right. The bony thorax was somewhat immobile with a decreased vital capacity and other evidence of pulmonary emphysema. Crepitant râles were constantly heard over the posterior right base. The heart revealed an occasional premature ventricular systole. The pulmonary second sound was accentuated. A short, soft blowing systolic murmur was audible over the base. T., 98.0°; P., 100; R., 15; B. P., 110/60. The palpable arteries were moderately sclerosed. The enlarged and firm spleen extended to just below the umbilicus.

Neurologic examination by Dr. Harry LeFever revealed a right facial weakness (supranuclear); weakness of the left masseter and pterygoid muscles; paresis of the right upper eyelid; deviation of the tongue to the right; impaired hearing on the right with bone conduction greater than air conduction; and unequal reflexes. These findings were interpreted as the result of a previous brain stem lesion, probably a hemorrhage.

Laboratory investigation confirmed the characteristic findings of congenital hemolytic icterus; an anemia, red blood cells 1,480,000, hemoglobin 5.0 Gm.; a reticulocytosis of 54 per cent; microcytosis; and increased fragility of the red blood cells, .319-471. The icterus index was 60. There was a leukopenia, 3,300 to 3,800. The blood N.P.N., glucose, and carbon dioxide combining capacity were normal. The urine revealed no bile but pathologic amounts of urobilin; it was otherwise normal. The stools contained bile pigment but occult blood was not demonstrable. The Wassermann and Kahn tests were negative. The direct van den Bergh test was negative; the indirect was 4.2 mg.

Upon this evidence a diagnosis of congenital hemolytic icterus, without biliary obstruction, seemed warranted. On the other hand, destruction of the red blood cells was gradually becoming more marked. During the first four hospital days the erythrocyte count decreased from 1,620,000 to 1,310,000, while the icterus index rose from 60 to 75; and the reticulocyte count from 54 to 70 per cent. These findings signified increasing hemolysis and indicated the onset of a "crisis," and an unfavorable course of the disease. The blood typing showed Group O; however, from our previous studies transfusion seemed contra-indicated. Since at this time three emergency splenectomies for hemoclastic crises had already been successfully accomplished, we had less hesitancy in advising this operative procedure as a means of arresting the threatening hemolytic process.

Kidney function tests were within normal limits. An E.K.G. revealed a normal

sinus rhythm with an occasional sino-auricular premature contraction; and left ventricular preponderance. Roentgenologic examination of the chest revealed increased broncho-vesicular markings. A flat film of the abdomen revealed evidence of gallstones.

Splenectomy was accomplished uneventfully February 13. Preoperatively morphine gr. $\frac{1}{4}$ and atropine gr. $\frac{1}{150}$ were administered. The usual left rectus incision was made after local novocaine infiltration anesthesia; and nitrous oxide-oxygen was administered during the exploration and splenectomy. Considerable yellow tinged ascitic fluid was encountered. The distended, thick-walled, opaque, and moderately adherent gallbladder contained three large calculi. Palpation of the biliary ducts revealed no evidence of stones. A small accessory spleen 15 Mm. in diameter was removed from the posterior splenic pedicle.

The spleen weighed 811 Gm. and measured $23 \times 16 \times 6.5$ cm. Supravital studies of the pulp revealed the usual increased phagocytosis of the red blood cells by clasmatocytes, atrophy of the lymphatic elements, and engorgement of the splenic parenchyma by erythrocytes. Grossly and microscopically the pathologic appearance was that of congenital hemolytic icterus. The usual postoperative autotransfusion was immediately apparent. Within the first 24 hours the erythrocytes had increased to 2,030,000 and the hemoglobin to 5.8 Gm.; with 11,900 leukocytes. Other than for some productive cough, subsequent convalescence was steady and uneventful. The icterus diminished and gradually disappeared. The reticulocyte count decreased. The patient's strength slowly returned and she was discharged March 6, 1935, 21 days postoperative, greatly improved.

Case 3.—O. L., a white housewife, age 52, was admitted to the Research Service June 7, 1935, presenting a purulent otitis media complicated by a progressively increasing anemia and a recently developed icterus.

A little over a year previously, while under hospital observation for goiter, a marked leukopenia and a moderate, sustained anemia and thrombopenia had been discovered. The white blood cells ranged from 1,200 to 2,500; the erythrocytes from two to three million. During the past year various medical regimens had been instituted in an attempt to overcome this status, with little apparent result. It was believed that her bone marrow was moderately hypoplastic. About two weeks ago, however, she developed an acute purulent otitis media, which ruptured the right tympanum, with a resultant profuse foul smelling discharge. Two days before admission a right facial palsy supervened. With the establishment of this infection more evident anemia developed, accompanied by definite clinical icterus for the first time. The leukopenia became more pronounced.

Upon arrival at the hospital the total leukocyte count was only 200. Hemolytic streptococci were cultured from the middle ear discharge. Direct smears showed contaminating bacilli and cocci. The icterus index was 40. The direct van den Bergh was negative; the indirect showed a trace. The red blood cell count was 1,200,000, with 18 per cent reticulocytes. The platelets were greatly diminished.

Owing to the atypical picture which she had presented during the past year, suggesting a hypoplastic bone marrow, a transfusion of 400 cc. of citrated blood was given, cautiously, soon after admission. This was followed by a chill and a severe reaction.

Upon physical examination a splenomegaly, hitherto absent, was discovered. The fragility test revealed some decrease in the resistance of the erythrocytes to hypotonic solutions. The icterus index had increased to 60. With evidence now available of an increasing hemolytic anemia, of increased erythrocyte fragility, of a rising reticulocyte count, of splenomegaly, of a mounting icterus index and of an even more marked leukopenia—the conclusion that we were dealing with an atypical congenital hemolytic icterus seemed warranted. Further investigation strengthened the view that we were now facing a definite hemoclastic crisis initiated by the middle ear infection, and splenectomy was determined upon.

On June 8, 1935, a 920 Gm. spleen was removed without incident under local anesthesia with supplementary nitrous oxide-oxygen. The liver and gallbladder appeared to

be normal, as did the other viscera. No accessory spleens were seen. Upon supravital study the splenic pulp was found to be greatly engorged with neutrophilic leukocytes, in sharp contradistinction to the extreme peripheral leukopenia. The phagocytic clasmato-cytes were greatly increased in number.

Convalescence was complicated by the development of a large rectal abscess with surrounding necrosis from which hemolytic streptococci, similar to those recovered from the otitis media, were cultured. This was treated by hot moist packs, by incision and drainage; and the danger of general sepsis was combated by repeated daily small blood transfusions (from June 11 to June 16). The rectal area healed slowly.

On July 3, 1935, the erythrocyte count was 3,610,000 with only 1.4 per cent reticulo-cytes. The leukocyte count, however, remained low—1,800—for some time. The patient was discharged July 6, 1935, definitely improved. She has been followed during the past year. On July 8, 1936, just one year after leaving the hospital, her blood picture showed: red blood cells, 4,250,000; hemoglobin, 13.0 Gm.; reticulocytes, 0.2 per cent; leukocytes, 5,100. This restoration to normal of the previously depressed blood findings is further evidence that we were dealing with the splenomegaly of congenital hemolytic icterus.

Case 4.—L. H., a white housewife, age 31, was referred to the Research Service by Dr. C. C. Fitzpatrick of Jackson, Ohio. She was admitted January 1, 1936, critically ill; and presented the picture of an acute hemoclastic crisis, *in extremis*.

Her early history is that of unrecognized congenital hemolytic icterus. She was in apparent good health up to about four years ago, when she had a cesarean section to terminate her third pregnancy. At that time an anemia and a splenomegaly were noted. Liver therapy was tried without appreciable effect. She was twice hospitalized and transfused. About a month ago liver therapy was resumed and six injections of liver extract were given. This resulted in some questionable improvement. One week ago, however, she was confined to bed because of increasing anorexia and weakness. Two days ago persistent nausea and vomiting developed. The resultant extreme dehydration and demineralization complicated the clinical picture on admission to University Hospital, with evidence of recent rapid loss of weight, of increasing anemia, with moderate jaundice and progressive dyspnea.

Physical examination revealed a critically ill patient. The skin was pale and icteric; the mucosae and finger tips were cyanotic; there was moderate dyspnea with orthopnea; no petechiae or other evidences of bleeding could be found, yet the anemia was profound. The sclerae were yellow. T., 99.6°; P., 122; R., 32; B.P., 118/50. The pulse was full. A blowing systolic murmur was audible over the entire precordium. The liver was moderately enlarged. The spleen extended to the iliac crest, and was tender. A pitting edema was demonstrable over the tibial crests. There were no abnormal neurologic findings.

Immediate examination of the blood revealed red blood cells, 800,000; hemoglobin, 2.1 Gm.; reticulocytes, 16 per cent; leukocytes, 10,800; platelets greatly decreased, and an icterus index of 60. The urine showed an albuminuria. The N.P.N. was 40 mg. per cent; the blood glucose 160 mg. per cent; the plasma CO₂ 30 vol. per cent; and the blood chlorides 205.

Intranasal oxygen was instituted. This resulted in some improvement of the cyanosis and dyspnea. A small indirect transfusion was given about three hours after admission. This was accompanied by chilliness, temperature elevation and some reaction. Later sodium bicarbonate and glucose were given intravenously and after four hours 500 cc. of citrated blood. Only slight transitory improvement was noted.

The relative lack of response in this critically ill patient, during the first 12 hours of medical treatment, left no alternative but splenectomy. While the rationale of this operative procedure had been established in our previous experiences, no patient had presented heretofore quite so critical a condition. It was decided to explore and limit the procedure to ligation of the splenic artery, in case adhesions or operative difficulties made the actual removal of the spleen too hazardous.

On January 2, 1936, without any preoperative medication, 150 cc. of novocaine containing eight drops of adrenalin per 100 cc. was infiltrated along the left upper rectus region. The spleen, exposed through an adequate left rectus incision, was large, bluish and fortunately nonadherent. Nitrous oxide-oxygen was then administered. The spleen was luxated and its pedicle freed. One-half cubic centimeter of adrenalin was next injected directly into the splenic artery. A definite, visible contraction of the spleen followed, thus squeezing blood cells from the large splenic reservoir into the circulation and effecting an autotransfusion. The pedicle was then clamped and tied and the spleen removed. Several accessory spleens, ranging from 3 Mm. to 3 cm. in diameter, were then removed from the region of the pedicle.

Immediate improvement occurred in the patient's clinical status, which allowed the abdomen to be thoroughly explored. The liver was enlarged. Its lobules were evident; however, it did not appear to be cirrhotic. The gallbladder was enlarged, firm, thickened and contained numerous irregular stones, which are so characteristic of the calculi occurring in instances of congenital hemolytic icterus. The ducts appeared to be patent. The stomach and colon were normal, and the pelvis was negative. The patient left the operating room definitely improved.

The spleen weighed 1,635 Gm. and measured 26 x 15 x 10 cm. Grossly it was characteristic of hemolytic icterus. Microscopic sections revealed a diffuse fibrosis and numerous dilated endothelial channels. Increased phagocytic activity was evident, as well as increased blood pigment. The splenic corpuscles were atrophic.

Postoperatively the blood pressure remained over 100 systolic. Hematology: red blood cells, 1,710,000; white blood cells, 23,700; hemoglobin, 3.9 Gm.; platelets, 350,000. Hypodermoclysis and intranasal oxygen were administered. At the commencement of the second day 600 cc. of citrated blood were given to hasten the clinical recovery. From that time on convalescence was progressive and uneventful.

On February 22, three weeks postoperative, the blood findings paralleled the clinical improvement. Red blood cells, 4,490,000; hemoglobin, 13.4 Gm.; white blood cells, 7,200; reticulocytes, 0.4 per cent; and platelets 1,890,000. The icterus index was also normal. The patient was discharged January 28. Six months later, on July 22, she was clinically well. Red blood cells, 5,420,000; hemoglobin, 14.9 Gm.; reticulocytes, 4 per cent; leukocytes, 8,400; icterus index, 6.2; and thrombocytes, 1,900,000.

Case 5.—G. P., female, age 4, with an acute severe hemoclastic crisis, was splenectomized September 6, 1933, by Dr. V. A. Dodd.¹

Case 6.—V. T., female, age 20, with an acute hemoclastic crisis, was splenectomized March 25, 1935, by Dr. Luke Zartman.¹

THROMBOPENIC PURPURA

Case 7.—E. M., a colored schoolgirl, age 17, was admitted to the University Hospital June 23, 1934, for the management of purpura with an attendant severe anemia. Unusual pallor together with scattered subcutaneous and submucous hemorrhages were evident.

She had been well and active up to early May, when unusual bleeding from the gums was first noted. This became more marked. Menstruation early in June was prolonged and profuse. An increasing pallor, with the symptoms of progressive anemia, caused her to consult a physician. She was hospitalized elsewhere June 14, and the presence of a severe anemia confirmed. A blood transfusion was given June 16. This resulted in but temporary relief, since the metrorrhagia continued and in addition epistaxis and hematemeses developed.

Her past history revealed a long recognized tendency to easy bruising. Nevertheless, she had undergone tonsillectomy eight years previously without any complications. No other incidence of unusual bleeding was known to have occurred in her family.

Upon entering the hospital the patient was dyspneic, somewhat cyanotic and perspiring profusely. T., 103°; P., 120; R., 48; and B. P. 103/?. Her pallor was striking.

Cutaneous petechial hemorrhages up to 5 Mm. in diameter were evident. The eyes reacted normally and the sclerae were clear. There were no retinal hemorrhages. The gums were spongy and hemorrhagic. Ulceration had developed about a carious and abscessed lower right molar, and had extended into the adjacent tongue and soft palate. Necrosis with resultant fetor oris was evident. Recent bleeding was also noted in the nasal cavities. The heart was negative, other than for a blowing systolic murmur heard at the apex. Pelvic examination revealed a cervical polyp and uterine bleeding. Other examinations were negative. The spleen was not palpable, and apparently not enlarged.

Investigation of the blood (Chart 2), revealed 1,770,000 red blood cells, hemoglobin 4.9 Gm. (Newcomer), color index 0.9, reticulocytes 57 per cent; erythroblasts 1,200; and normoblasts 2,400 per cmm.; mean erythrocyte diameter 8.6 microns with both anisocytosis and poikilocytosis extreme on direct examination but with no "sickling," immediate or delayed; erythrocyte fragility was markedly decreased, hemolysis started at 0.319 and was not complete until something less than 0.210 salt equivalent; icterus index 6; leukocytes 30,000, with 67 per cent actively motile, mature, neutrophilic granulocytes, 5 per cent myelocytes C and metamyelocytes, 1 per cent eosinophils, 18 per cent lymphocytes, and 9 per cent monocytes; blood platelets 3,500; bleeding time 23 minutes; coagulation time (Howell) 11 minutes; calcium time 12 minutes; prothrombin time 12 minutes; no clot retraction in 24 hours; tourniquet test (50 Mm. of mercury) showed innumerable petechiae after ten minutes. The Wassermann and Kahn tests were negative; carbon dioxide combining power 36; blood Group O. Doubtless due to the oral infection and anemia the daily temperature ranged from 99° to 104° F. Blood cultures were negative.

The striking thrombopenia together with the coagulation findings pointed to the diagnosis of idiopathic thrombopenic purpura hemorrhagica. Elsewhere a diagnosis of aplastic anemia with symptomatic purpura had been entertained. However, both the red and white cells in the circulating blood revealed such evident regenerative responses that an aplastic bone marrow was at once ruled out. The unusually high reticulocyte count (57 per cent) even resembled that seen occasionally in congenital hemolytic icterus, or in pernicious anemia after liver therapy. A sternal bone marrow puncture yielded no added information. The nucleated red cell response (3,600 per cmm.) added further evidence of unusually active erythropoiesis. Even after an epinephrine test June 26 (Chart 2), blood platelets did not appear in the peripheral circulation. In fact, platelets were essentially absent throughout the entire period of preoperative observation (Chart 2).

Intensive medical treatment was first instituted. During the first 24 hours 50 cc. of whole blood were given intramuscularly. On the second day 500 cc. were given intravenously. Viosterol, a high fat-protein diet, large amounts of orange juice daily, oral hygiene, and even cauterization and packing of the cervical canal were of little avail, since the hemorrhagic tendency and anemia steadily increased. Splenectomy was finally advised, but was refused until the fourth hospital day when the red blood cells following a profuse hemorrhage fell to 725,000 and the hemoglobin to 2.4 Gm. The nucleated red cells had increased to 6,000. The leukocytes were 25,000, the reticulocytes 30 per cent and *no platelets were to be found in the peripheral blood*. An emergency transfusion of 700 cc. of citrated blood was given to the comatose and moribund patient, which increased the red blood count to 1,230,000. A second of 400 cc. was given later in the day. The following day (June 28) the general clinical condition of the patient was greatly improved. Red blood cells, 1,660,000; hemoglobin, 4.9 Gm.; leukocytes, 10,800; platelets, 0; T., 99.6°; P., 88; R., 24; and B. P., 100/58. It was thereupon decided to resort to surgery without further delay and to attempt ligation of the splenic artery, if splenectomy seemed inadvisable.

On June 28 splenectomy was accomplished uneventfully with a minimal loss of blood. A left rectus incision was made under local anesthesia, which was supplemented by nitrous oxide-oxygen, for the intra-abdominal manipulation. No free fluid was

encountered in the abdomen. Petechial hemorrhages, however, were numerous and were increased by the necessary handling of the viscera. The spleen was normal in size, appearance and position. Its pedicle was short. It weighed 225 Gm. At the conclusion of the operation the pulse was 96, respirations were 24, the blood pressure was 140/90; red blood cells 1,990,000, reticulocytes 15 per cent, hemoglobin 5.9 Gm., leukocytes 14,800, and blood platelets 21,900. Twenty-four hours after the splenectomy the leukocyte count was 52,000 with 85 per cent active mature neutrophils, red blood cells 2,230,000, hemoglobin 6.2 Gm., and blood platelets 89,000 (Chart 2). All bleeding had ceased.

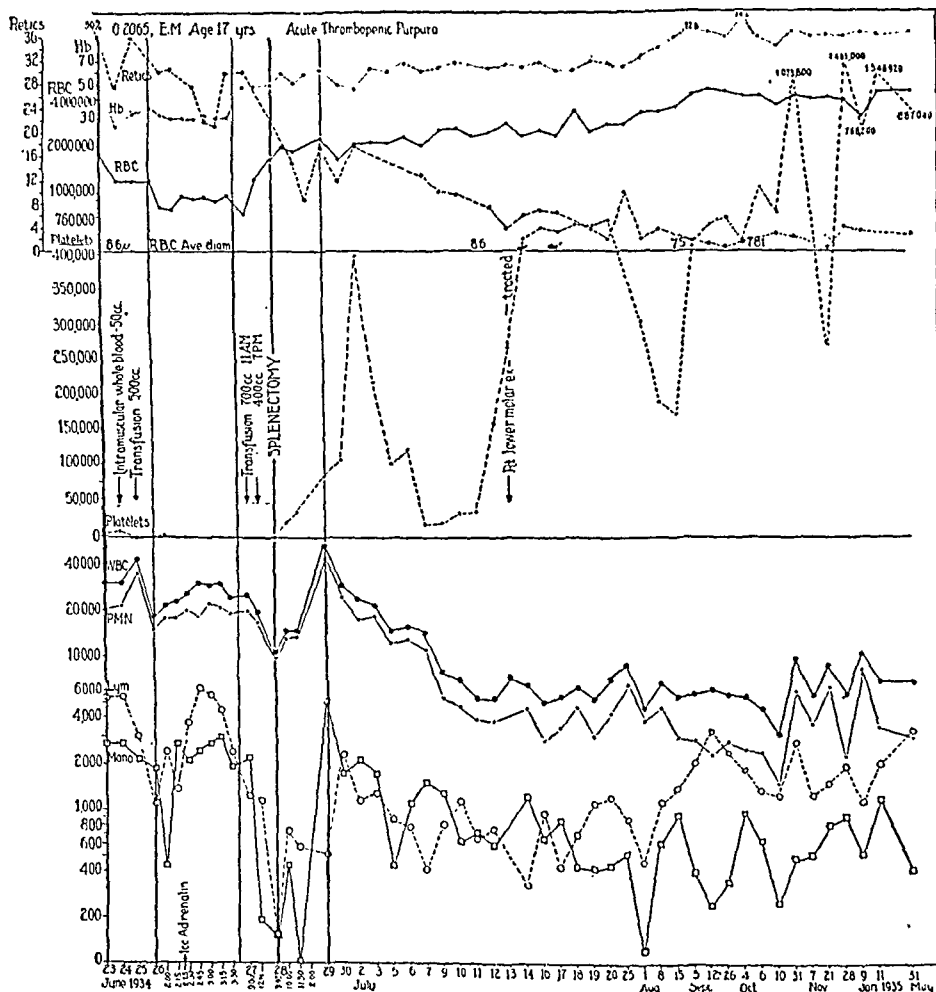


CHART 2.—(Case 7) Splenectomy for the hemoclastic (thrombocytoclastic) crisis of thrombopenic purpura. (Journal A.M.A.¹)

Investigation of the fresh splenic pulp by the supravital technic failed to reveal free extracellular clumps of blood platelets. The debris in the clasmatoocytes presumably represented whatever of these elements had reached the spleen. This permitted an explanation for the failure of platelet increase subsequent to the preoperative injection of epinephrine. Microscopically sections of the spleen revealed a suggestion of chronic inflammation. The splenic corpuscles were prominent but normal. The clasmatoocytes did not appear to be increased in number or unusually phagocytic. The reticulum was hypoplastic; the endothelial cells and the vascular bed were not remarkable. The splenic pulp was not engorged with red blood cells as occurs in hemolytic icterus, nor with blood platelets, as is described in certain purpuric states.

Immediately following the splenectomy the blood platelets increased in number until on the fourth day postoperative they attained a count of 395,000. During this period

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they varied greatly in individual size. During the succeeding eight days a gradual decrease ensued without notable change in the patient's condition. By the twenty-second postoperative day they had reached 748,000 (Chart 2).

With the cessation of the hemorrhages and the attainment of satisfactory convalescence the ulceration of the mouth cleared rapidly. The abscessed molar was extracted on the fifteenth postoperative day and the gums were then given needed attention. Both the hemoglobin and red cells gradually increased. At the end of three weeks there were 3,500,000 erythrocytes. The reticulocytes promptly decreased (Chart 2). The bleeding time became normal, clot retraction occurred promptly and the tourniquet test (ten minutes at 50 Mm. mercury pressure) failed to cause petechiae. By the ninth day postoperative the elevated temperature and pulse had returned to normal. The patient was discharged July 20, on the twenty-second postoperative day, in good condition.

During the past two years she has maintained an entirely normal existence, with a platelet count sustained consistently at about one million per cmm. (Chart 2). She

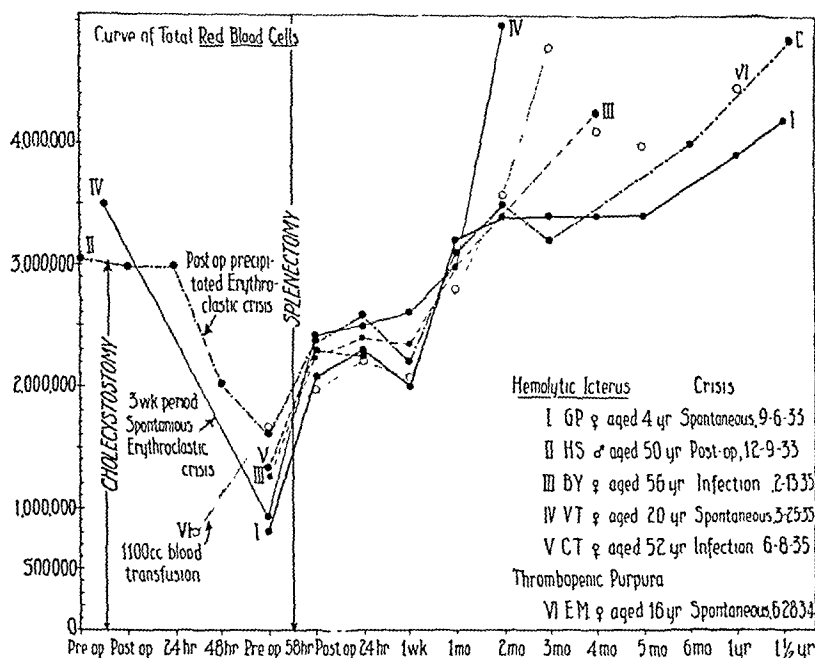


CHART 3.—The results of splenectomy for hemoclastic crises in six cases. (Journal A.M.A.¹)

has married and, on March 21, 1936, gave birth to a normal female child. Throughout this stay under observation in the University Hospital, from March 20 to 30, 1936, no evidence of recurrence of the purpuric state was noted. The platelet count remained high. There was no unusual bleeding either previous to or after labor. The puerperium was quite normal. She continues to remain clinically well.

Case 8.—A. J., a housewife, age 61, with an acute hemoclastic crisis occurring in the course of thrombopenic purpura, was successfully splenectomized June 30, 1936. She was dismissed in good condition on July 30. This splenectomy was accomplished after the completion of this paper.

CONCLUSIONS

The evidence presented by these eight patients, all successfully surviving a major surgical procedure during a hemoclastic crisis, further supports the rationale of splenectomy in the treatment of properly selected and prepared patients suffering from hemolytic icterus or thrombopenic purpura of splenic origin. There have, thus far, been no failures. We attribute this success to careful differential diagnostic studies, optimum preoperative management

and the application of modern surgical knowledge to the problem. The implications of this study add materially to our knowledge of the pathologic physiology of the spleen.

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AN ANATOMIC RESTUDY OF THE PELVIC LYMPHATICS*

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THE two principal problems of the proctologist are infection and malignancy. In each of these processes the lymphatics are important factors. In a subsequent paper the possible relationship between lymphopathia venereum and rectal stricture will be presented; in that paper use will be made of the findings set forth in the present report.

An excellent account of the pelvic lymphatic structures could be crystallized from the various studies that have been made. However, because of the lack of any particular interest on the part of the authors in clinical proctology, no one of the well known studies correlates this field. Several of the modern French workers are interested in lymphatics as they pertain to the spread of malignant disease, and in so far as this interest pertains to the lower bowel, their studies are very informative. Of the considerable study that was made of the literature, only cursory mention can be made, later in the paper.

The present anatomic restudy of the genito-anorectal lymphatics was begun in order to correlate the more general studies with the special point of view of the proctologist. In order properly to evaluate the field it has been necessary to acquire first hand familiarity with actual anatomic preparations. A series of these has been prepared.

Anatomic Terminology.—Dr. Collier F. Martin has repeatedly stated that much confusion exists with regard to the terminology of anorectal anatomy. The appended nomenclature is that favored by Doctors Martin and Batson and is significant anatomically, physiologically, pathologically and clinically:

The anus is the external opening of the anal canal (a rima in the anatomic sense).

The anal canal represents the terminal portion of the large intestine, from the anus to the anorectal line, a distance of approximately 2.5 cm. The entire lining is modified squamous epithelium.

The term "anal skin" is used to replace the misnomer "anal mucous membrane."

The terms "anorectal line," "pectinate line," "dentate line," "dentate margin," and "mucocutaneous junction" are synonymous. They all refer to the boundary line between the anal canal and the rectum, comprising the anal papillae with the intervening delicate margins of the anal valves.

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The terms "white line of Hilton" and "intersphincteric line" are synonymous, but they were thought by Hilton, and by many others, to be synonymous also with "anorectal line." Hilton's white line is more readily felt than seen. It is definitely within the boundaries of the anal canal; it lies approximately half way between the anus and the anorectal line. In fact, in many individuals, the intersphincteric line is rendered distinct only during digital examination of the anus, the finger displacing the internal sphincter upward, so that temporarily the internal and external sphincter muscles become actually superior and inferior muscles, respectively. This displacement during examination probably accounts for the errors which are to be seen in some drawings.

The material studied consisted of human fetuses at or near term, of new-born infants, and of isolated segments obtained from the adult at operation and at necropsy. A few studies were made on the dog and on the human *in vivo*.

The materials injected were the radio-opaque colloidal suspension of thorium dioxide, known as thorotrast; the vital dye brilliant benzo blue 6 B. A. extra conc., and the often used substances, air, mercury and Gerota's solution.

STUDIES IN VIVO.—Based on the work of Hudack and McMaster² with the injection of vital dyes several studies were carried out. With the cooperation of Dr. I. S. Ravdin several injections, 0.1 cc. each, of expertly purified benzo blue 6 B. A. extra conc. were made intradermally into the closely shaved skin of the living dog; the areas used were the abdominal surface and the inner surface of the hind leg. The lymphatic collecting vessels filled rapidly and became clearly visible. Dye injected into the skin of the lower part of the abdomen and of the inner surfaces of the hind legs was carried quickly to the groin on the corresponding side. Lymphatic vessels arising from the skin of the upper part of the abdomen led to the axilla on the corresponding side. Three similar injections of benzo blue 6 B. A. extra conc. were made into the skin of normal humans, and several into the anal and peri-anal skin of patients. The results of these studies were valueless.

Because of these disappointing results the experiment was repeated on the skin of the dog. The lymphatics were again quickly and clearly demonstrated, and were readily followed for 10 cm. after nine to 15 seconds.

With a living female dog under amytal anesthesia, injections of benzo blue 6 B. A. extra conc. were made with the aid of a speculum, into the posterior vaginal wall at intervals from the introitus to, and including, the posterior lip of the cervix. The presacral nodes and the nodes at the bifurcation of the great vessels were clearly demonstrated within three minutes. Direct injections were made into the wall of the bladder, uterus, rectum, colon and small bowel; the lymphatics were visualized almost immediately.

Anatomic Study of the Lymphatics.—Air serves well for the demonstration of lymphatics, but the preparations are evanescent. The most satisfac-

tory results in this study were, however, obtained from the use of Gerota's solution and of mercury.

Thirty-five specimens (fetuses at, or near, term and new-born infants) were available for this research. Of this number, 14 were found satisfactory for study. The lymphatic drainage of the pelvic viscera, excluding the urinary tract, is summarized in Table I.

TABLE I

THE LYMPHATIC DRAINAGE OF THE PELVIC VISCERA, EXCLUSIVE OF THE URINARY TRACT

Viscera	Drainage Pedicles
Rectum	(1) Superior hemorrhoidal. (2) Middle hemorrhoidal (hypogastric). ^{5,7}
Anus	(1) Inferior group (inguinal).
Vagina	(1) Superior or external iliac. (2) Middle or hypogastric (3) Inferior { lateral sacral pedicle of sacral promontory. ⁵
Cervix	(1) Anterior or external iliac. (2) Middle or hypogastric. (3) Posterior { lateral sacral. pedicle of sacral promontory. ⁵
Uterus (and Adnexa)	(1) Lumbar. (2) External iliac. (3) Lateral sacral. (4) Inguinal.
Prostate	(1) Anterior or external iliac. (2) Middle or hypogastric. (3) Posterior { lateral sacral. ⁵ pedicle of sacral promontory. ⁵

EXPERIMENTAL RESULTS

Anus.—Within the thickness of the anal and peri-anal skin is a lymphatic plexus of origin, the meshes of which are so finely patterned that a good mercurial injection resembles, in the cleared specimen, a solid layer of mercury (*b* in Fig. 1 *left*, and *d* in Fig. 1, *right*). More careful inspection of the plexus reveals the "nodular" appearance of the minute lymphatics resulting from the numerous valves within them and from overdistention by the injected mass.

From the lateral and anterior margins of the peri-anal plexus arise numerous larger collecting vessels which are among the afferent vessels of the inguinal nodes. These trunks, averaging eight to ten in number on each side, lying in the subcutaneous tissue, pursue a rather irregular course to the inguinal nodes (*c,c* in Fig. 1, *right*). Some of them lie in the genitocrural fold; others lie along the medial surface of the thigh. The collectors bifurcate and anastomose frequently along their course. The nodes (*d,d* in Fig. 2, *left*) appear as little tufts of mercury, giving rise in turn to efferent trunks which lead to the next nodal station. The efferents of the inguinal nodes lead to external iliac or to common iliac nodes (*e* in Fig. 2, *left*), the name depending on that portion of the

iliac vessels with which the nodal group is in relation. From the superior portion of the anal lymphatic plexus several small vessels can be seen to cross the anorectal line and to ascend along the rectal wall (*e* in Fig. 2, *right*). Hence there are definite anastomoses between the lymphatic plexuses of origin of the anal canal with those of the rectum.

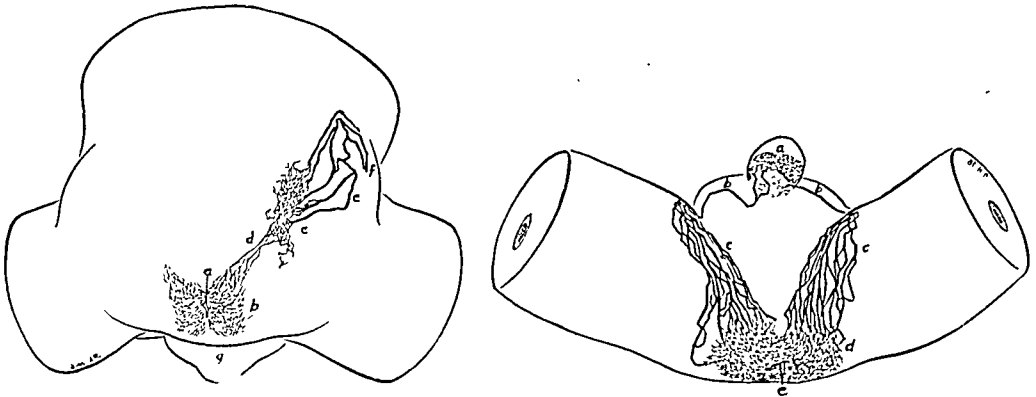


FIG. 1.—(*Left*) Peri-anal and gluteal lymphatics (posterior view) of a male, white fetus at term. Injections made along the anal margin and in the skin over the gluteal region, using mercury. (*a*) Anus. (*b*) Network of the peri-anal skin. (*c*) Plexus of the skin over the gluteal region. (*d*) Anastomotic vessels. (*e*) Collecting vessels. (*f*) Collecting vessels from the superior gluteal region passing to the groin. (*g*) Scrotum. (*Right*) Penile and peri-anal lymphatics, viewed from below, in the same specimen as that represented in Fig. 1 *left*. Injections made in the skin of the shaft, using mercury. (*a*) Network of the skin of the shaft of the penis. (*b,b*) Collecting vessels from the network of the shaft. (*c,c*) Collecting vessels from the peri-anal network. (*d*) Network of the peri-anal skin. (*e*) Anus.

Punctures made in the skin overlying the coccyx and lower part of the sacrum reveal a dense superficial network anastomosing freely with the peri-anal plexus, inferiorly, and with the superficial lumbar lymphatics or with the gluteal lymphatics, superiorly. Communications across the median line are plentiful (Fig. 3, *left*).

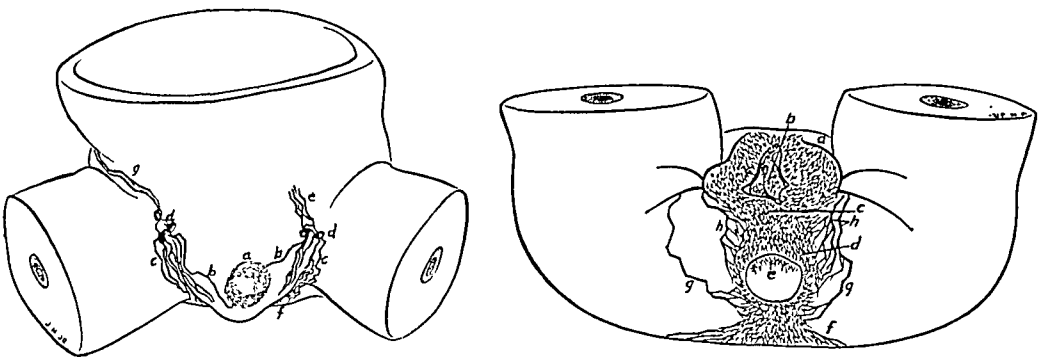


FIG. 2.—(*Left*) Lymphatics of the skin of the shaft of the penis (anterior view) in the same specimen as that represented in Fig. 1. Injection made in the skin of the shaft, using mercury. (*a*) Network of the skin of the shaft of the penis. (*b,b*) Collecting vessels from the network of the shaft. (*c,c*) Collecting vessels from the peri-anal network. (*d,d*) Inguinal nodes. (*e*) Beginning of the external iliac chain of the collecting vessels. (*f*) Network of the peri-anal skin. (*g*) Collecting vessels from the superior gluteal region. (*Right*) Peri-anal lymphatics and lymphatics of the external genitalia of a female, colored fetus at term viewed from below. The anus was dilated before fixation. Injections made in the skin overlying the lumbar, gluteal and sacrococcygeal regions, in the anal skin, in the skin of the fourchet and in the skin of the base of the right labium majus, using mercury. (*a*) Superficial lymphatic network of the labium majus. (*b*) Superficial network of the labium minus. (*c*) Superficial network of the fourchet. (*d*) Peri-anal network. (*e*) Anal network showing the origin of the vessels which ascend in the rectal columns of Morgagni. (*f*) Sacrococcygeal network. (*g,g*) Collecting vessels from the postanal plexus (sacrococcygeal). (*h,h*) Collecting trunks from the peri-anal and anal networks.

If the buttock be roughly divided into an upper and outer half and a lower and inner half, punctures along this line of division reveal two possible destinations for the injected material (Figs. 1, *left*, and 3, *left*). It may pass to the peri-anal plexus by way of the vessels of the lower and inner half of the buttock. Again, it may find its way upward

THE PELVIC LYMPHATICS

and outward, following the curve of the iliac crest, reaching the superficial external inguinal nodes (*c* in Fig. 3, *right*, and *g* in Fig. 2, *left*). Finally, as clearly shown in Figs. 1 *left* and 3 *left*, the material may fill both of these sets of vessels, thus completely encircling the limb.

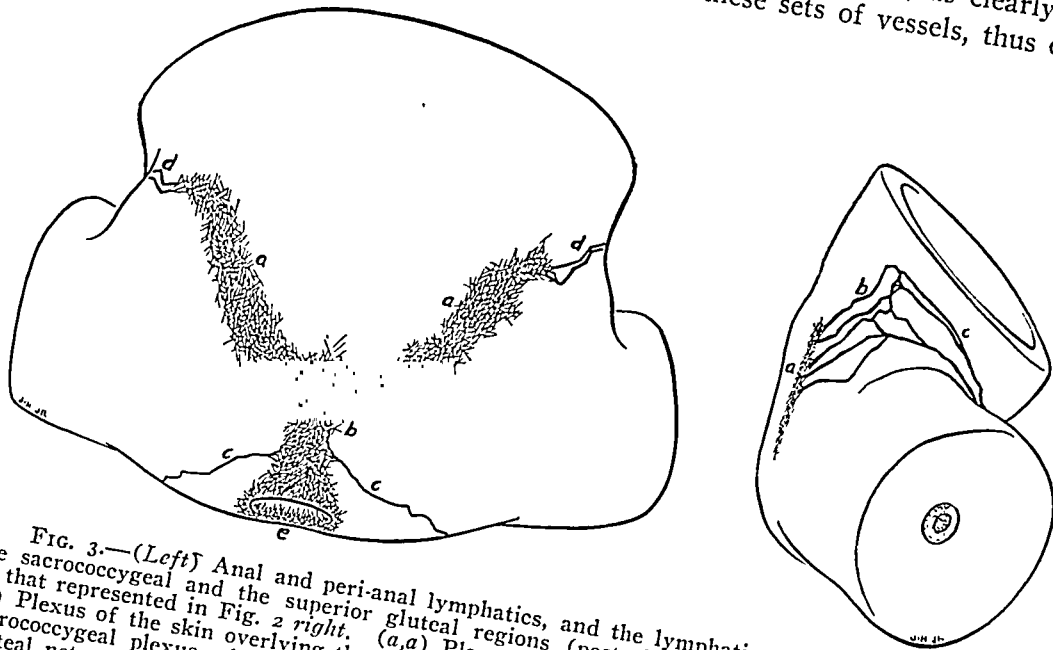


FIG. 3.—(*Left*) Anal and peri-anal lymphatics, and the lymphatics of the skin overlying the sacrococcygeal and the superior gluteal regions (posterior view) in the same specimen as that represented in Fig. 2 *right*. (*a,a*) Plexuses of the skin of the superior gluteal region. (*b*) Plexus of the skin overlying the sacrococcygeal region. (*c,c*) Collecting vessels from the sacrococcygeal plexus which pass to the groin. (*d,d*) Collecting vessels from the superior gluteal plexus passing to the groin on either side by way of the superior route, following the curve of the iliac crest. (*e*) Anal network showing the origin of the vessels which ascend in the rectal columns of Morgagni. (*Right*) Lymphatics of the skin of the superior gluteal region (lateral view) in the same specimen as that shown in Fig. 1. (*a*) Network of the skin over the gluteal region, using mercury. (*b*) Collecting trunks passing to the superior of the superior route, following the curve of the iliac crest.

Rectum.—In a coronal section of the rectum (Fig. 4, *left*) the anastomotic vessels which leave the anal plexus (*c*) to cross the anorectal line (*b*) and pass upward in the rectal wall, can be seen to lie within the columns of Morgagni (*a,a*). At the base of

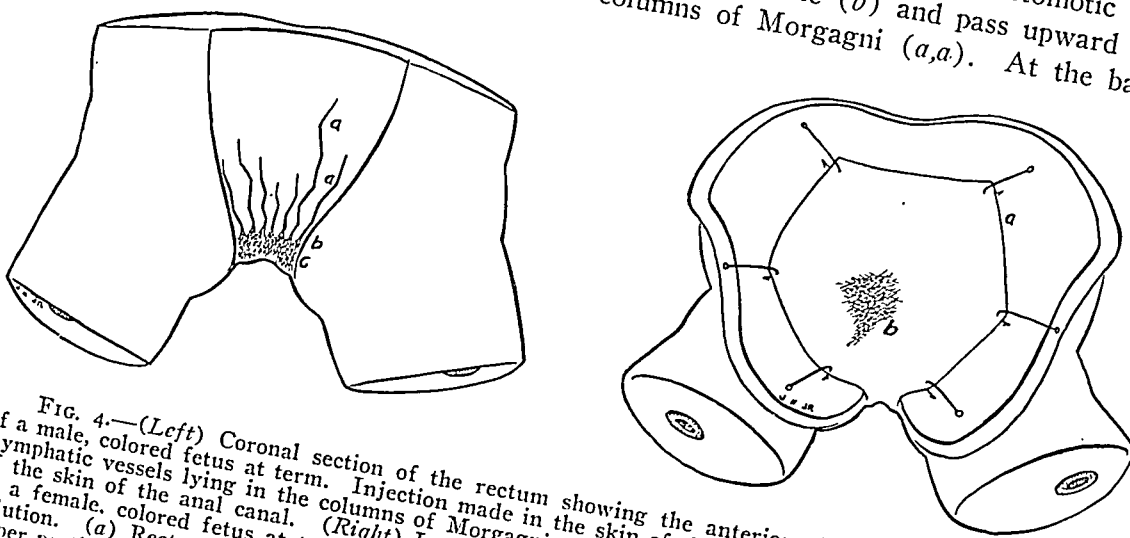


FIG. 4.—(*Left*) Coronal section of the rectum showing the anterior view of the posterior half of a male, colored fetus at term. Injection made in the skin of the anal canal, using mercury. (*a,a*) Lymphatic vessels lying in the columns of Morgagni. (*b*) Level of the anorectal line. (*c*) Network of the skin of the anal canal. (*Right*) Lymphatics of the rectal mucous membrane (anterior view) of a female, colored fetus at term. Injection made in the rectal mucous membrane, using Gerota's solution. (*a*) Rectum laid open. (*b*) Network of the rectal mucous membrane in the region of the upper portion of the ampulla.

each column (at the anorectal line) the anal lymphatics are gathered into a small tuft, from the apex of which one or two vessels ascend within the column for a distance of 1 to 3 cm. The mucous membrane of the lower portion of the rectal ampulla does not possess

a well developed lymphatic plexus (Fig. 4, *left*, and 4, *right*). Above the columns, however, the rectal mucous membrane presents a rich network of lymphatics, although the demonstration of these vessels is difficult. Gerota's solution does not distend the lymphatics so well as does mercury. Hence a plexus can be more easily studied in a preparation in which Gerota's solution is employed (Fig. 5, *left*). The question arises as to

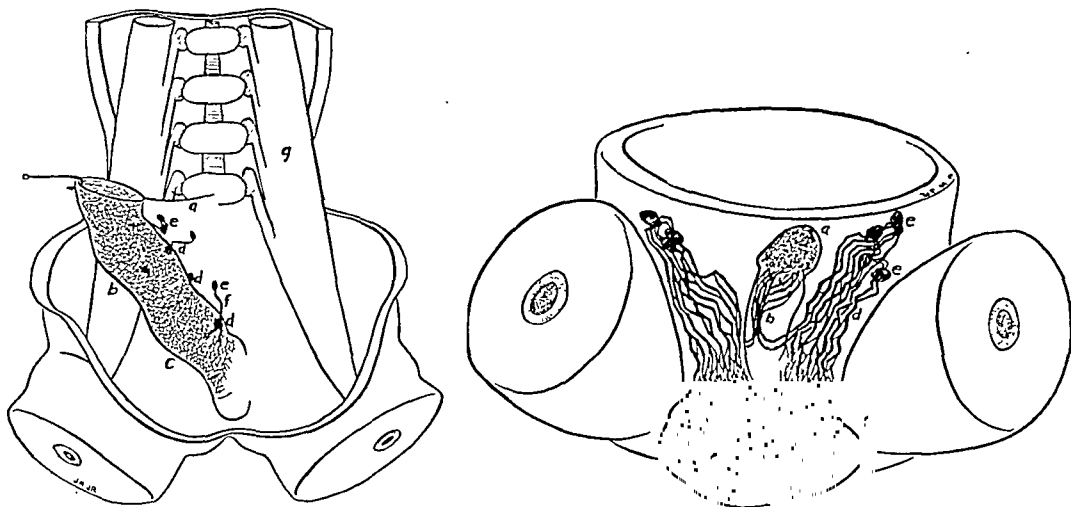


FIG. 5.—(*Left*) Lymphatics of the lower sigmoid and of the upper rectum (anterolateral view) of a male, white fetus at term. Injection made in the muscular layer of the gut, using Gerota's solution. (a) Cut edge of the mesosigmoid. (b) Network of the muscular layer of the sigmoid colon. (c) Network of the muscular layer of the rectum. (d,d,d) Pararectal nodes of Gerota. (e,e) Intermediate nodes lying in the mesentery. (f) Collecting vessel. (g) Psoas major muscle. (*Right*) Lymphatics of the glans penis and of the scrotum (anterior view) of a male, colored fetus at term. Injections made in the mucous membrane of the glans, and in the skin of the scrotum, using mercury. (a) Network of the mucous membrane of the glans. (b) Collecting vessels from the glans. (c) Network of the skin of the scrotum. (d) Collecting vessels from the glans and from the scrotum. (e) Superficial inguinal nodes.

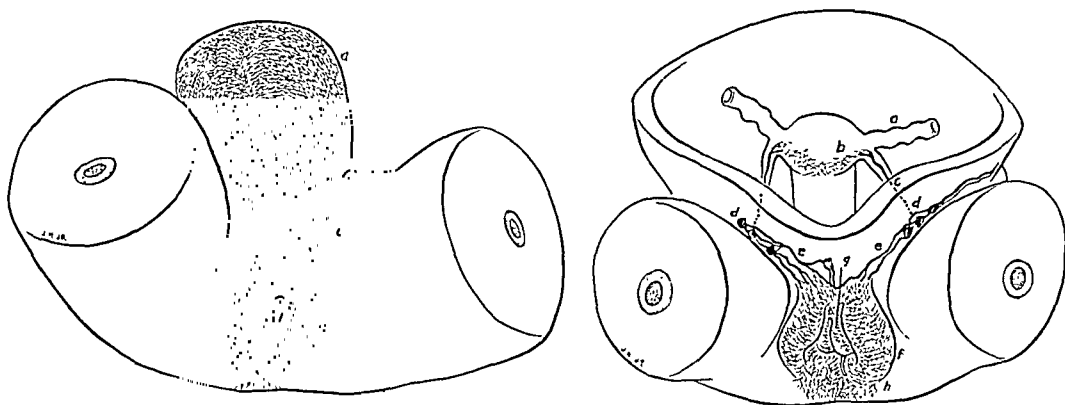


FIG. 6.—(*Left*) Scrotal, perineal and peri-anal lymphatics, viewed from below, of a male, colored fetus at term. Injections made in the peri-anal skin, in the skin of the perineum, and in the skin of the scrotum, using mercury. (a) Network of the skin of the scrotum. (b) Perineoscrotal collecting vessel. (c) Network of the skin of the perineum. (d) Network of the peri-anal skin. (e) Anus. (*Right*) Lymphatics of the external genitalia and of the round ligaments in the same specimen as that shown in Fig. 2 *right*. External genitalia injected as described for Fig. 2 *right*. Injections made also in the muscular layer of the uterine fundus, using mercury. (a) Fallopian tube. (b) Network of origin of the lymphatics of the round ligaments. (c) Collecting trunk of the round ligament passing to an inguinal node at d. (d,d) Inguinal nodes. (e,e) Collecting vessels from the superficial plexuses of the external genitalia. (f) Superficial network of the labium majus. (g) Superficial network of the labium minus. (h) Superficial plexus of the fourchet.

how this plexus can be distinguished from a vascular capillary network. In a gross study, such as this, the presence of the injected material in blood capillaries cannot be entirely eliminated. A deciding factor, however, is the successful injection of the collecting trunks, of the intermediate nodes, and of the regional nodes if possible. In Fig.

5, *left*, showing the lymphatic networks of the muscular layer of the rectum and of the lower part of the sigmoid, collecting vessels can be seen arising from the networks of origin at (b) and at (c) and passing to pararectal nodes (d,d,d) and to the nodes lying in the mesentery (e,e). These collecting trunks are the afferent vessels of nodes lying along the course of the inferior mesenteric artery. Some lie at the bifurcation of the superior hemorrhoidal artery, a few at the point of origin of the inferior sigmoid artery, a few at the origin of the left colic artery, and several at the root of the inferior mesenteric artery itself. The rectal lymphatic plexuses anastomose freely with those of the sigmoid at the rectosigmoid juncture.

Scrotum.—The rich lymphatic plexus of the scrotum is readily demonstrable by injections in, or near, the median raphé. One or two punctures usually suffice to fill the entire system. The collecting trunks arise near the raphé, swing laterally, receiving other collectors from the more lateral portions of the scrotal plexus, pass upward to the cruroscrotal fold, and finally end in the superficial inguinal nodes (c, d, and e in Fig. 5, *right*). The network of origin communicates posteriorly with the plexuses of the anus and perineum, laterally with those of the inner surface of the thighs, and anteriorly with that of the skin of the penis (Figs. 5, *right*, and 6, *left*).

Penis.—The lymphatics of the skin of the penis, like those of the scrotum, present a delicate plexus of origin along the raphé. Collecting vessels from this network pass around the penis to a

pathway which lies superficially along its dorsum. Collecting trunks which drain the distal portion of the penis are obviously longer than those arising in the proximal portion. These vessels, on reaching the root of the organ, turn laterally to reach the superficial inguinal nodes of the corresponding side (a,b,b, Fig. 1, *right*, and a,b,b, Fig. 2, *left*). The proximal communications of the penile integumentary lymphatics are stated in the foregoing. Distally, these vessels anastomose with those of the prepuce, which in turn communicate with the lymphatics of the glans.

A single puncture in the glans penis is usually sufficient to demonstrate a very fine, dense plexus (a in Fig. 5, *right*). The collecting vessels gather on either side of the frenum and then swing dorsally, uniting as they do so, in three or four trunks which lie on either side of the deep dorsal vessels of the penis (b in Fig. 5, *right*). At the root of the organ they swing laterally, as do the other collectors, to the inguinal nodes on either side. The lymphatics of the glans anastomose with those of the distal portion of the urethral mucous membrane.

Vulva.—The lymphatic drainage of the external genitalia of the female is analogous to that of the external genitals of the male. Figs. 2 *right* and 6 *right* represent a specimen in which two punctures served to inject the entire system of the external female genital organs. One injection in the fourchet filled all the vessels of both labia minora, of the vestibule, of the clitoris, and of the left labium majus. One additional injection at the base of the right labium majus filled the remaining vessels. In this specimen the

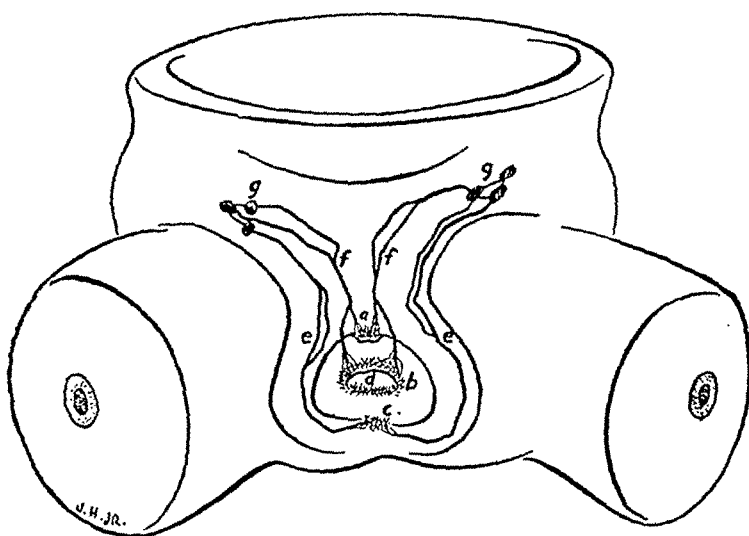


FIG. 7.—Deep lymphatics of the external genitalia of a female, colored fetus at term (anterior view). Injections made in the clitoris, in the skin of the vestibule, and in the skin of the fourchet, using mercury. (a) Network of the clitoris. (b) Superficial vestibular network surrounding (d) the vaginal introitus. (c) Superficial network of the fourchet. (e,e) Deep collecting vessels from the fourchet. (f,f) Deep collecting vessels from the networks of the vestibule and of the clitoris forming a coarse presymphyseal plexus. (g,g) Inguinal nodes.

plexuses of the labia majora (*a* in Fig. 2, *right*, and *f* in Fig. 6, *right*), are so dense that it is impossible to view the underlying collecting trunks which drain the fourchet, vestibule and clitoris. In Fig. 7 are shown the deeper trunks (*e,e*) which drain the area of the fourchet (*c*). These vessels, two on each side, lie in the subcutaneous tissue of the labium majus, the contour of which they follow in their course to the inguinal nodes. Medial to these collectors are the two deeper trunks (*f,f*) which arise, one on each side, from the upper portion of the vestibular plexus (*b*), and from the network of the clitoris (*a*). These collecting vessels enter into the formation of a coarse pre-symphyseal lymphatic plexus which, in some subjects, presents one or more small nodes. The free lymphatic anastomoses among the various parts of the external genitals is evident; one injection filled nearly the entire system on both sides, which is not an uncommon occurrence in the study of lymphatics.

Vagina.—Injection of the lymphatics of the vagina must be performed with as little dissection of the organ itself as possible. Removal of the anterior abdominal wall, of the anterior bony wall of the pelvis, and of the bladder and urethra provides good exposure of the vagina. The anterior vaginal wall is sectioned along the median line to the anterior lip of the uterine cervix. Punctures can then be made in the vaginal mucosa at any level. Again, intramuscular injections can be made along the posterior vaginal wall in the region of Douglas' cul-de-sac, with little or no dissection of the recto-vaginal septum.

The vaginal lymphatic system presents two networks of origin, one mucosal and one muscular, which communicate with a perivaginal plexus giving rise, in turn, to the collecting vessels (Poirier and Cunéo⁵). The delicate mucosal network (*b* in Fig. 8) communicates inferiorly, at the introitus, with the vestibular vessels, and superiorly with the cervical vessels. In Fig. 8 are shown four collecting trunks arising from the left side of the perivaginal plexus. The two lower trunks (*h*) swing upward following a rather long but direct course to the lateral sacral nodes (*q*). The upper trunks (*i*) pass downward for a very short distance and then turn sharply upward. One of them ends in a lateral sacral node (*q*), the other turns laterally to reach a hypogastric node (*t*).

In Fig. 9 is shown the posterior perivaginal lymphatic plexus (*c*) which, together with the lymphatics of the anterior wall of the rectum (*d*), lies in the rectovaginal septum. The collecting vessels (*e*) of the vaginal network swing posteriorly, in the rectal stalks, to reach the lateral sacral node (*f*). One vessel (*i*) arises from the uppermost portion of the vaginal network, turns laterally, and ends in a node of the external iliac group (*j*).

Uterine Cervix.—The cervical lymphatic plexus of origin (*c* in Fig. 8) continuous below with that of the vagina (*b*), and above with that of the body of the uterus (*d*), is drained by collectors which ordinarily have two points of destination. The lowest cervical trunk (*k* in Fig. 8), dips downward for a short distance on the posterolateral surface of the vagina; it then turns upward to join the lateral sacral pedicle (*u*) of the vagina. The remaining cervical trunks in this preparation pass directly upward to reach the lateral sacral nodes, thus constituting the lateral sacral pedicle (*l*) of the cervix. In this same figure is shown an additional drainage pedicle. On the left side a cervical trunk of the upper group passes obliquely upward (*m*) in the broad ligament to join those vessels which constitute the lumbar pedicle (*r*) of the uterus. This is not a constant finding, having been noted but three times in 30 subjects by Cunéo⁵ and Marcille. In Fig. 9 is shown a collecting trunk (*h*) of the external iliac pedicle, arising from the upper portion of the cervix and from the lower portion of the uterine body and passing laterally to end in nodes (*j*) which are in relation with the external iliac vessels.

Uterus.—The mucous, muscular and peritoneal networks of the uterus contribute to a subperitoneal plexus from which the collectors arise (Poirier and Cunéo⁵). This dense network, shown clearly in Fig. 8, *d* and *e*, is easily filled by random punctures in the muscular layer. The smaller collecting vessels arise near the median line on the anterior and posterior surfaces of the body of the uterus. They converge at the sides

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of the uterus in such a manner as to form a "lymphatic ring." At *c* in Fig. 8, the fundus points directly toward the observer. The transparent preparation demonstrates this lymphatic ring clearly.

Collecting trunks from the lower portion of the body of the uterus may follow those of the cervix, which end in the nodes of the external iliac group (Fig. 9, *h*), or they may join the lateral sacral pedicle of the cervix as in Fig. 8, *l*. Thus the external iliac nodes may receive collecting vessels from the vagina, from the cervix and from the uterine body. The lateral sacral nodes may also receive afferents from the vagina, from the cervix, and from the body of the uterus.

One or two trunks arise from the anterior surface of the uterine fundus, just below the cornua, and accompany the round ligament on either side (*b* and *c* in Fig. 6,

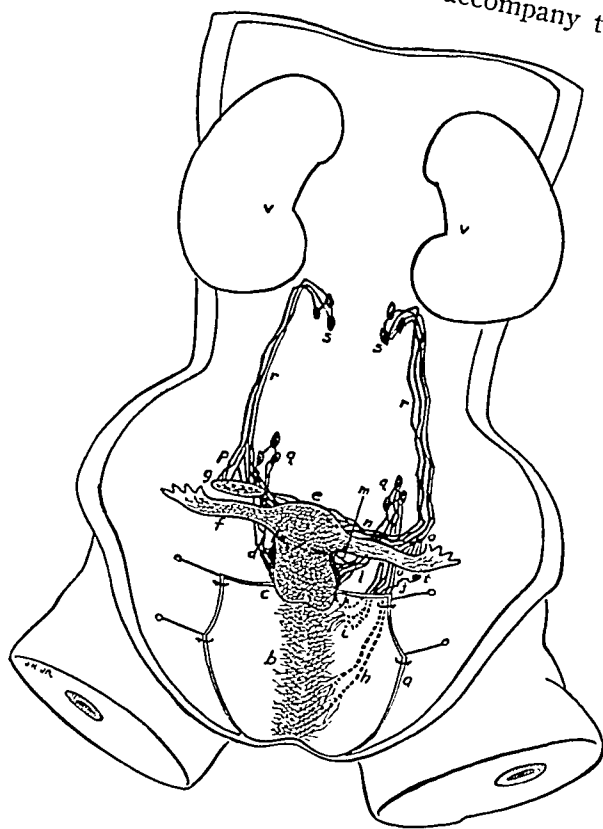


FIG. 8.

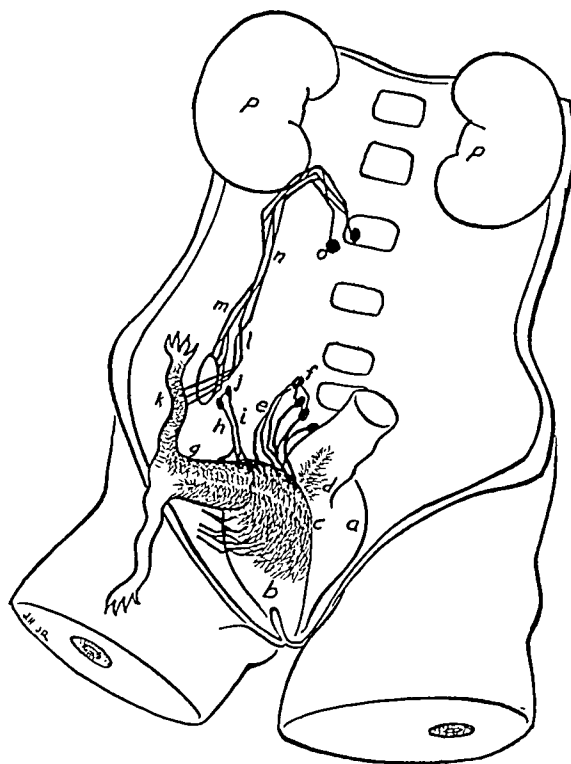


FIG. 9.

FIG. 8.—Lymphatics of the internal genitalia of a female, colored fetus at term (anterior view). Injections made in the mucous membrane of the vagina, posterior wall, in the muscular layer of the posterior lip of the cervix, in the muscular layer of the fallopian tubes, and in the ovaries, using Gerota's solution. (a) Vagina laid open to show the posterior wall. (b) Vaginal network. (c) Cervical network. (d) Network of the uterine body. (e) Network of the uterine fundus. (f) Network of the fallopian tube. (g) Network of the ovary. (h) Collecting vessels from the inferior portion of the vagina. (i) Collecting vessels from the superior portion of the vagina. (j) Collecting vessel from the vagina passing to a hypogastric node, *t*. (k) Collecting vessel which joins vessels *h* and *i* to form the lateral sacral pedicle of the vagina. (l) Collecting vessel from the upper portion of the uterus. (m) Cervical collecting vessel which passes upward to join the abdominal pedicle of the uterus. (n) Collecting vessels from the uterine fundus and from the upper portion of the fallopian tube entering into the abdominal or lumbar pedicle *r*. (o) Collecting vessels entering into the abdominal pedicle *r*. (p) Ovarian collecting vessels entering into the abdominal pedicle *r*. (q,q) Lateral sacral nodes. (r,r) Abdominal or lumbar pedicles. (s,s) Juxta-aortic nodes. (t) Hypogastric node. (u) Lateral sacral pedicle of the vagina. (v,v) Kidneys.

FIG. 9.—Lymphatics of the internal genitalia of a female, colored fetus at term (anterolateral view). The left broad ligament was sectioned near its lateral attachment, allowing the uterus to be partially rotated and displaced to the right. Thus the observer obtains a posterior view of the uterus and a posterolateral view of the right. The posterior vaginal wall, in the muscular layer of the uterus and fallopian tubes, and in the ovaries, using Gerota's solution. (a) Muscular network of the cervix, of the uterus and of the rectum. (b) Vagina. (c) Posterior perivaginal lymphatic network. (d) Lateral sacral nodes. (e) Uterine network. (f) Collecting vessel of the external iliac pedicle, from the vagina. (g) External iliac nodes. (h) Collecting vessel of the fallopian tube. (i) Collecting vessels from the fallopian tube entering into the abdominal or lumbar pedicle. (j) Ovarian collecting vessels entering into the abdominal pedicle. (k) Abdominal or lumbar pedicle. (l) Juxta-aortic nodes. (p,p)

right). The destination of these collectors is the inguinal group of nodes (*d* in Fig. 6, *right*).

The upper portion of the body of the uterus and the greater part of the fundus are drained by an abdominal or lumbar pedicle (*r* in Fig. 8). This group of collectors (*n* in Fig. 8) comprises from three to six vessels which swing laterally in the suspensory ligament of the ovary, and then upward, behind the ovary, accompanying the ovarian vessels. These lymphatic vessels lie on the anterior surface of the psoas muscle behind the peritoneum. In their upward course they cross the ureter, lying anterior to it. Opposite the lower pole of the kidney they bend medially at various angles to end in the juxta-aortic nodes (*s* in Fig. 8, and *o* in Fig. 9).

Ovary and Oviduct.—An injection made directly within the substance of the ovary (*g* in Fig. 8) usually serves to demonstrate the rich plexus of the hilum (*p* in Fig. 8).

The lymphatics of the fallopian tube (*f* in Fig. 8, and *k* in Fig. 9) are readily filled by means of a puncture near the horn of the uterus.

Collecting vessels from the ovary (*p* in Fig. 8, and *m* in Fig. 9) and from the tube (*o* in Fig. 8, and *l* in Fig. 9) join those of the lumbar pedicle (*r* in Fig. 8, and *n* in Fig. 9) of the uterus, the course and destination of which have been described in the foregoing.

DISCUSSION.—This study indicates that the anorectal lymphatic collectors run in two pedicles, one inferior and one superior; the anorectal line is the boundary between the two networks of origin. The inferior pedicle carries vessels which end in the inguinal nodes. In the superior pedicle the lymphatics accompany the branches of, and the tributaries to, the superior hemorrhoidal vessels.

The present study does not demonstrate the additional components of the inferior pedicle of the anorectal lymphatics described by Rouvière⁷ and by Villemin, Huard and Montagné.⁹

Quénu,⁶ in 1893, described a middle hemorrhoidal ganglion (lymph node). This has been verified by Gerota, Cunéo, and Marcille and Boulay (Mondor⁴). However, Mascagni³ indicated such a node in one of his illustrations.

The position of the middle hemorrhoidal node varies. It may lie along the course of the middle hemorrhoidal artery or it may be found at the point of origin of this vessel from the hypogastric artery. The afferent vessel or vessels of this node are pictured (Poirier and Cunéo⁵) as lying on the levator ani muscle and as arising in the region of the anal musculature. The present study yields no evidence, whatsoever, of the middle or hypogastric pedicle described by Poirier and Cunéo. Mondor⁴ stated that the nodes of the middle pedicle are not often involved by metastases. Chlyvitch¹ expressed the belief that this pedicle is rare and that it is the least important of the three.

Mondor stressed the group of nodes situated at the bifurcation of the superior hemorrhoidal artery as being the "ganglion principal du cancer du rectum." He mentioned also the possibility of the occurrence of inguinal adenopathy in carcinoma high in the rectum, attributable to anastomoses between rectal and anal lymphatics. These connections were confirmed three times in the present study.

Sappey⁸ has described the lymphatics of the anus and of the genitalia

very well, but made no mention either of rectal lymphatics or of the anastomoses between the lymphatics of the rectum and those of the anus.

The description offered here of the lymphatics of the external genitalia, in both sexes, does not differ in any essential points from those given in the literature on the subject. Likewise, the accepted descriptions of the lymphatics of the body and fundus of the uterus, of the fallopian tubes, and of the ovaries are confirmed by the results of the present research. However, with regard to the lymphatics of the vagina and of the uterine cervix, there are certain points which merit further discussion, as far as their relation to proctology is concerned.

Poirier and Cunéo described three groups of vaginal collecting vessels, a superior or external iliac pedicle, a middle or hypogastric pedicle and an inferior group which ends either in nodes of the sacral promontory or in a lateral sacral node. Rouvière⁷ considered only two principal groups of vaginal collecting trunks, one accompanying the uterine artery and the other the vaginal artery. The former corresponds to the external iliac pedicle of Poirier and Cunéo, the latter to the hypogastric pedicle. Rouvière added that, rarely, vaginal collectors may reach the nodes of the promontory. The present study supports the existence of a lateral sacral pedicle and of a hypogastric pedicle. In none of the preparations was any evidence found of a vessel passing to the nodes of the promontory. However, it is shown that the lateral sacral group of collectors drains both the superior and the inferior portions of the vaginal tract. Furthermore, the hypogastric trunk is seen to arise from the upper third of the vagina rather than from the middle third. The external iliac pedicle is here confirmed as described in the accepted accounts. Rouvière believes that one cannot establish a definite distinction between the collectors arising from the different portions of the vagina.

The same three pedicles mentioned by Poirier and Cunéo in their description of the vaginal lymphatics were again mentioned by these authors in connection with the absorbents of the uterine cervix. Rouvière termed these groups anterior, hypogastric and posterior respectively, because of their relative positions within the pelvic cavity. The present study yields evidence of the anterior and of the posterior pedicles, but fails to demonstrate a hypogastric group. Rouvière stated that the disposition of the lymphatic collectors is subject to numerous and important variations.

As has been stated, the present study confirms the accepted descriptions of the lymphatics of the body and of the fundus of the uterus. This work also indicates the occasional existence of a lateral sacral uterine pedicle in addition to the lumbar, external iliac and inguinal pedicles.

The lack of evidence of the existence of certain groups of lymphatic vessels, however, does not necessarily mean their nonexistence. It does, however, indicate either the technical difficulty of injection or a difference in the anatomic structure of the material studied. Many of the specimens in this series were obtained from Afro-American subjects.

SUMMARY.—The lymphatics of the perineum and pelvis were studied *in vivo* and in anatomic specimens with particular reference to their relation to proctologic problems.

The study of the methods of demonstrating lymphatics *in vivo* is only partially complete. Of particular interest is the vital dye, brilliant benzo blue 6 B. A. extra conc., which was shown to be useful for the visualization and study of visceral lymphatics *in vivo*. This extends the work of Hudack and McMaster on cutaneous and subcutaneous lymphatics.

As to the studies on anatomic specimens, previous authors have covered the subject well, but none of them has had the more specific, clinical field of proctology in view. All of the previously described genito-anorectal lymphatic channels, with the exception of two, have been confirmed. As to those channels which could not be confirmed, namely the middle hemorrhoidal or hypogastric pedicle of the anorectal lymphatics and the pedicle of the sacral promontory receiving vessels from both the vagina and the cervix, it is not evident whether they were not found because of some fault in technique, or whether they were absent in the material examined. The fact that many specimens in this series were from subjects of Afro-American stock, which was not the case in earlier series, may be pertinent.

CONCLUSIONS

Of particular interest in this study in relation to present clinical problems, is the difference in the lymphatic drainage of the genital tract in the two sexes. In the male the lymphatic drainage from the genitalia is for the most part inguinal. In the female the lymphatic drainage from the external genitalia is inguinal, as in the male, but the drainage from the vagina and from the cervix is pelvic.

Of the pelvic lymphatics draining the female genital tract, the most important, from the standpoint of posterior spread of vaginal or of cervical infection, or of metastases from neoplasm, are those lying in the rectovaginal septum and those lying in the uterosacral ligaments or rectal stalks.

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TRANSURETHRAL RESECTION*

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THE idea of attempting to overcome obstructions at the bladder neck by means of transurethral manipulations is not new. The historical side of this subject has been presented by various authors during the past few years and those interested in this phase of the subject may refer to these various publications.^{1, 2}

With the development of a new armamentarium for the non-surgical relief of bladder neck obstruction, widespread interest in electro-resection has been manifested both by the medical profession and the public. No surgical subject in urology, since the fulguration treatment of bladder tumors by Beer,³ has received as much attention and discussion as has resection.

From a review of recent publications and discussions it is evident that definite ideas are beginning to crystallize regarding the selection of cases suitable for resection, its value and limitations, as well as the results obtained.

The statement seems justified that three different points of view exist today regarding the selection of cases suitable for resection.

(1) With the introduction of any new procedure in our armamentarium one finds a group of enthusiasts who take up the new procedure with great eagerness and in this particular instance believe that this method will replace, or even has already completely replaced, surgical prostatectomy.

(2) On the other hand, one finds another group who are just as decided in their views as the first group and who believe that surgical prostatectomy for various reasons is still the method of election.

(3) In the third group one finds urologists who are of the opinion that there is a definite place in our armamentarium for both transurethral resection and surgical prostatectomy. These men willingly admit without controversy that resection is the method of choice in the treatment of bars and contractions, small middle lobes, and, in some of the cases, of small lateral lobes, but that large hypertrophies should be treated by surgical prostatectomy. In other words, this group is of the opinion that one should make a rather careful selection of cases and not fit every patient to any one form of treatment.

It is at this point that there will naturally arise differences of opinion regarding the procedure to be employed in a given case. One surgeon may express his opinion that the prostate is too large to be resected and that a prostatectomy should be performed; whereas, another will state that resection is possible and will carry it out.

My experience in a relatively large number of patients has coincided with the latter opinion; and I think that the recommendation for resection or prostatectomy may be influenced by the personal preference of the surgeon.

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I have performed many resections, without difficulty of any kind, in patients who were told that this procedure was impossible. It is interesting to note the large number of doctors who come in for resection, despite the fact that they were told they needed open surgery.

On one point, however, there is very definite agreement, namely, in the treatment of carcinoma all agree that transurethral resection is the method of election combined with radium or deep roentgen therapy.

In trying to determine in my own mind the value and limitations of resection I have, as far as possible, approached this problem with an open mind and without prejudice.

My own position in this discussion can best be summarized by saying that during the past 51 months I have performed only one surgical prostatectomy and that during the same time I have refused resection to one patient only. This patient, a bad cardiac, was given suprapubic drainage until his cardiac function improved so that resection could be carried out. It is evident, therefore, that there has been no selection of cases, irrespective of the size of the prostate, the nature of the enlargement, or the physical condition of the patient.

From my experience in performing transurethral resections several very definite impressions have been gained; and while these views may not coincide with the views of others, I wish to present them at this time, realizing that perhaps some of you will not agree with me.

There is no doubt of the fact that the period of hospitalization is much shorter with resection than it is with surgical prostatectomy, and while this fact may not be of much importance to a small percentage of patients, I believe, all things being equal, it is an economic factor of enough importance to demand attention. Not only does this apply to the private patient, but also to the ward patient, as a result of which many more patients can be treated in a given period of time, hence making our ward services available to a larger number. The average stay in the hospital was seven days except when a preliminary suprapubic cystostomy was required, and in these cases the average stay was 20 days.

The number of patients in whom preliminary suprapubic cystostomy was employed became less and less as time went on. During the past three months only one preliminary cystostomy was done. On the other hand, I believe a cystostomy is indicated when catheter drainage fails because of chills, fever, pain, or bleeding, or when small stones with severe infection are present, or large stones.

Based on my experience with resection, I am convinced of the fact that resection has made it possible for a large number of patients to obtain relief from their prostatic condition who, because of serious coexisting disease in other important organs, were very poor surgical risks and, as a matter of fact, were refused prostatectomy elsewhere. It seems justifiable to state that if this procedure is of necessity the method of choice in the patient who is a very poor risk and hence cannot undergo a surgical prostatectomy with safety, the assumption that it should be made available to every patient who is a good risk is unquestionable.

It is not an uncommon experience to have a patient sent in by his physician with the request that a resection be performed because the patient is not a good risk for prostatectomy. The following instance is a good example of this type of case.

Case 1.—A. G., aged 76, admitted to the Presbyterian Hospital, March 1, 1936.

Present Complaint.—Frequency of urination for five years with gradually increasing severity; nocturia that has gradually increased, for three years. The day and night frequency accompanied with a great deal of pain on urination. During the past year there has been a good deal of difficulty in starting the stream; it was necessary to strain a long time before the urine would flow. Urgency and imperative urination during the past three weeks.

Physical Examination.—Pupils equal and reacted somewhat slowly to light. Numerous coarse and squeaking râles in the lungs; breath sounds at both bases tubular in character. The apex heart beat was not located; the sounds, of very poor quality. Abdomen: marked diastasis of the recti and a double inguinal hernia. Bladder dulness reached to the umbilicus. Liver palpable one inch below the costal arch. Rectal examination: a three plus enlargement of the prostate that was smooth and firm. Seminal vesicles could not be felt. The edema of the feet and ankles and legs extended almost to the head of the fibula. Lips and finger tips, cyanotic.

Laboratory Data.—Blood: red cells, 4,250,000; white cells, 10,800; hemoglobin, 74 per cent. Blood pressure: systolic, 170; diastolic, 70. Urine: albumin, 3 Mm.; sugar, 0; blood, +; leukocytes, 5,000. The colon bacillus was cultured from the urine. Blood chemistry: urea nitrogen, 14.3; creatinine, 1.2; nonprotein nitrogen, 33.2.

Roentgenologic Examination.—A marked diverticulosis of the colon and a bilateral hernia of the diaphragm. Multiple stones in the bladder. A small, contracted bladder with multiple cellules and small diverticula in the cystogram.

Indwelling catheter drainage was carried out for eight days.

Diagnosis.—Bilateral diaphragmatic hernia; diverticulosis of colon; bronchial asthma and emphysema; bundle branch block; myocardial damage; hypertension; arteriosclerosis; benign hypertrophy of the prostate; vesical calculi; chronic cystitis; bilateral inguinal hernia; diverticula of bladder, and hydrocele.

Operations.—On March 9, 1936, under sacral anesthesia, a transurethral resection was performed and a very large middle lobe and two rather large lateral lobes were removed. On March 16, 1936, under sacral anesthesia, a litholapaxy was performed. The patient had an uneventful convalescence. Discharged from the hospital, March 22, 1936.

Another interesting observation noted was the fact that the number of cardiac cases seeking relief showed a very definite increase. Whereas, in the days of surgical prostatectomy about 35.8 per cent of the patients suffered from cardiovascular lesions, a recent study of my resection cases showed 64.3 per cent, an increase of 28.5 per cent. This may be due to the fact that a more careful study of each case was made and hence more heart lesions were found than formerly. An electrocardiogram was made in each case prior to resection, and furthermore there is no doubt in my mind of the fact that more cardiacs were sent in for resection than were sent in for open prostatectomy because of the lower mortality rate.

Many of the patients with hypertension have been sent in with the request that a resection and not a prostatectomy be performed. The highest systolic pressure found was 260, and a resection was performed without the slightest difficulty.

The following case is presented as an example of a patient with a severe heart lesion.

Case 2.—M. C., aged 75, admitted to the Presbyterian Hospital, November 26, 1935.

Present Complaint.—Complete retention for ten days during which time he has been catheterized three times a day. There is some mental confusion.

Physical Examination.—A fairly well preserved elderly man. Head and neck, negative. Lungs, considerable wheezing at the left base posteriorly and moist râles. Heart, enlarged; irregular in rhythm; the sounds of poor quality; pulse, that of an auricular fibrillation. Abdomen, negative. Rectal examination: a two plus enlargement of the prostate that was smooth and regular.

Laboratory Data.—Blood: red cells, 4,350,000; white cells, 7,810; hemoglobin, 88 per cent. Blood pressure: systolic, 142; diastolic, 60. Urine: sugar, 0; albumin, 0; blood, 0; red blood cells, 0; white blood cells, 140; casts, 0. Blood chemistry: urea nitrogen, 14.8; creatinine, 1.4; nonprotein nitrogen, 32. Phthalein test: a total of 62 per cent of the dye eliminated in one and one-half hours.

Electrocardiogram.—Auricular flutter; ventricular extrasystoles; myocardial damage.

Roentgenologic Examination.—Negative for stone. A small bladder with trabeculated margin and some out-pouching from the left toward the base in the cystogram.

After three weeks of indwelling catheter drainage, bed rest and heart medication, the patient showed great improvement.

Diagnosis.—Coronary disease; auricular fibrillation and flutter; cardiac decompensation; cardiac hypertrophy and dilatation; myocardial damage; chronic bronchitis, and benign prostatic hypertrophy.

Operation.—On December 19, 1935, under sacral anesthesia, a transurethral resection was performed. The patient developed postoperative bleeding on January 6, 1936, three weeks after the resection. Two bleeding vessels were found; they were fulgurated and the bleeding promptly stopped. Patient discharged from the hospital January 17, 1936.

The importance of a careful study of the renal function requires no emphasis at this time, nor is it necessary to call attention to the fact that resection should never be performed until the renal function, if impaired, has been restored to normal or at least until it has become stabilized.

In the largest number of cases the improvement in renal function with treatment is rapid, as judged by the results of the functional tests as well as by the patient's general condition. In this group of patients the problem of determining the most opportune time for resection offers no serious problem.

I wish, however, to discuss the group of cases with badly impaired renal function in which the response to treatment was very slow and the improvement hardly perceptible, and the functional tests remained fixed at a high, or relatively high, level. At times these levels were very high so that the danger of renal insufficiency was an opposing factor in case the patient was to be operated upon. It is in this group that the decision to operate or not to operate is very difficult and at times greatly taxes one's clinical judgment. There is no doubt in my mind that in just this type of case transurethral resection should be the operation of choice and certainly carries with it less risk than does surgical prostatectomy. As an illustration of this type the following case is presented.

Case 3.—C. E., aged 57, referred by Dr. J. B. Herrick, was admitted to the Presbyterian Hospital, January 10, 1936.

Present Complaint.—Frequency of urination, urgency, burning, dribbling, and noc-

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turia. These symptoms had been present for ten years. Patient has had pain in the epigastrium for ten years, nausea and vomiting for several months, and very tarry stools for several days.

Physical Examination.—Moderately well nourished; exceedingly pale and sallow. Head, neck and lungs, negative. Heart enlarged to the left; a systolic murmur at the apex. Examination of the abdomen showed a large tumor mass extending four finger-breadth above the umbilicus. Liver, palpable. Rectal examination: a one plus enlargement of the prostate, smooth, with no signs of carcinoma.

Laboratory Data.—Blood: red cells, 2,520,000; leukocytes, 9,850; hemoglobin, 44 per cent. Blood pressure: systolic, 150; diastolic, 96. Urine: albumin, 0; sugar, 0; blood, 0; leukocytes, 0. Blood in the stool. Blood chemistry: urea nitrogen, 105.6; creatinine, 6.3. Phthalein test: only a trace of dye excreted in one and one-half hours (Table I).

Roentgenologic Examination.—Negative for stone. A set of intravenous pyelograms showed no visualization. Further studies by Doctor Herrick established the fact that the patient had a duodenal ulcer and a polyp in the pyloric antrum.

A catheter was passed into the bladder and gradual decompression instituted. This required 21 days. The patient was given three blood transfusions, each 500 cc. of whole blood.

TABLE I
SUMMARY OF THE FUNCTIONAL TESTS IN CASE 3

Date	Urea N.	Creatinine	N.P.N.	Phthalein Test	
				Appearance Time	% in 1½ hrs.
1-11-36	105.6	6.3	.....	
1-13				45 min.	Trace
1-16	69.8	3.7	74.4		
1-23	83.3	2.9	102.6	42 min.	Trace
1-29	102.5	2.6	123.0		
2- 6	129.0	2.9	142.9		
2-12	91.8	2.7	125.8		
2-17	90.1	2.9	105.3	55 min.	Trace
2-24	58.8	2.7	74.1		
3- 2	55.1	2.5	86.7		
3- 4	55.6	2.5	72.7		
3- 8				10 min.	11%
3- 9	56.2	2.3	92.2		
3-18	59.2	2.4	76.2		
3-21				19 min.	30%
3-23	54.0	2.9	70.2		
3-30	54.4	2.6	61.5		
3-31				12 min.	26%

Diagnosis.—Polyp of stomach; ulcer of duodenum; marked secondary anemia; hypertension; severe hemorrhage from intestinal tract; benign prostatic hypertrophy; chronic urinary retention; marked renal insufficiency; bilateral hydronephrotic atrophy of kidneys.

Operation.—On April 1, 1936, a transurethral resection, under sacral anesthesia, was performed. The patient had an uneventful convalescence. Discharged from the hospital on the fifteenth postoperative day.

I cannot agree with those who believe that because resection carries with it a much lower mortality rate, it is a relatively simple procedure, and that careful, detailed preoperative study and preparation can be dispensed with

and resection instituted at once. It seems to me that this is both poor teaching and poor practice. Because of the large number of cases that I have seen with serious organic disease,⁴ not only in the upper urinary tract but in other organs, I believe it is absolutely necessary to obtain a careful history, as well as make a complete physical examination in each case and carry out the necessary preoperative treatment.

As my experience with resection has widened I have operated upon a certain group of cases without preliminary catheter drainage. Heretofore all patients who had four ounces or more of residual urine were given preliminary catheter drainage. At the present time no preliminary drainage is em-

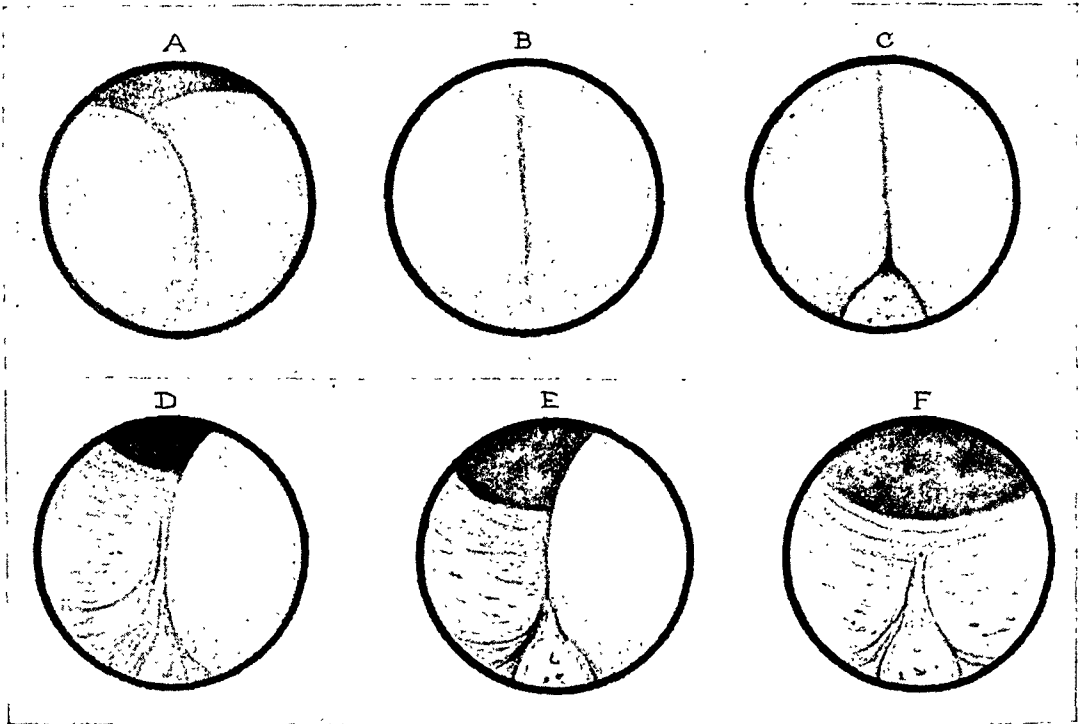


FIG. 1.—(A) Showing a small view of the bladder cavity and the presence of two large lateral lobes. (B) Showing the presence of the lateral lobes and the very markedly narrowed urethra. (C) Showing the lateral lobes and the verumontanum. (D) Partial removal of the right lobe. (E) Complete removal of the right lobe. (F) Complete removal of both lobes. The verumontanum is intact.

ployed in a patient in whom the residual urine does not exceed six ounces, provided the urine is clear, the renal function normal, and the heart and lungs are in good condition.

Preliminary cystoscopy is no longer carried out as a routine; once the diagnosis of prostatic obstruction has been made the type of enlargement is determined at the time the resection is performed. The exception to this rule is in case the history is not typical for prostatic obstruction, there is a history of one or more attacks of hematuria, and the cystogram shows a filling defect.

After the sheath has been passed into the bladder the examining telescope is introduced and the bladder cavity examined for tumors and stones. A search for diverticula is also made and finally the configuration of the bladder orifice is determined (Fig. 1 A, B and C).

The bladder orifice is next examined with the retrograde lens, and a good deal of information is obtained regarding the size of middle lobe and bars (Figs. 2 A and B and 3 A). Hypertrophy of the interureteric ligament and the resulting pouch behind it can best be demonstrated with the retrograde lens. When these conditions are marked I always resect the hypertrophied interureteric ligament.

The third and last step is the examination of the prostatic urethra to determine the size and extent of the intra-urethral enlargement and its relationship to the verumontanum (Fig. 1 C).

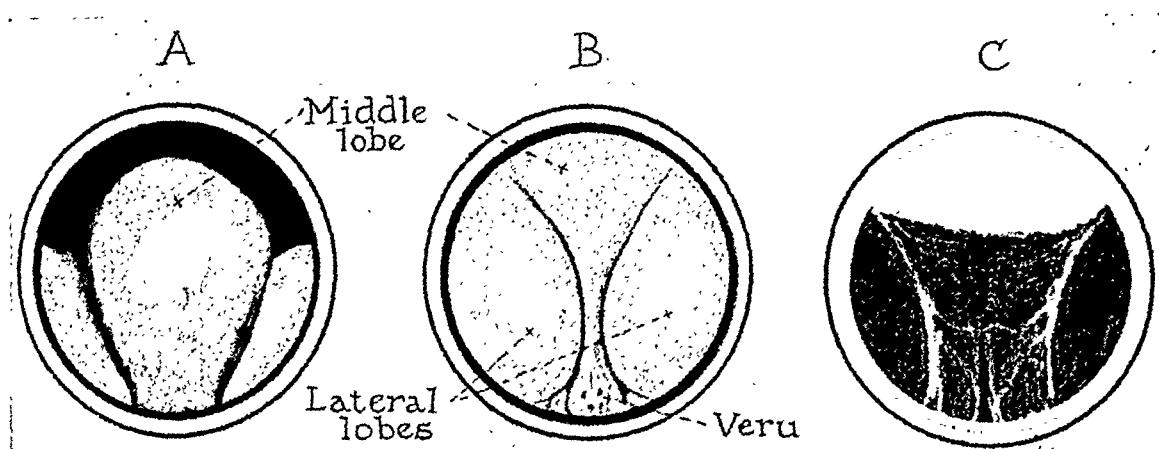


FIG. 2.—(A) Showing the presence of a large middle lobe. (B) View showing the lateral lobes, the middle lobe, and the verumontanum. (C) Beginning resection of the middle lobe.

POSTOPERATIVE REACTIONS.—The general opinion seems to prevail that following resection there are fewer postoperative complications and that when they do occur they are not so severe and are relatively much shorter in duration. I can subscribe to these views.

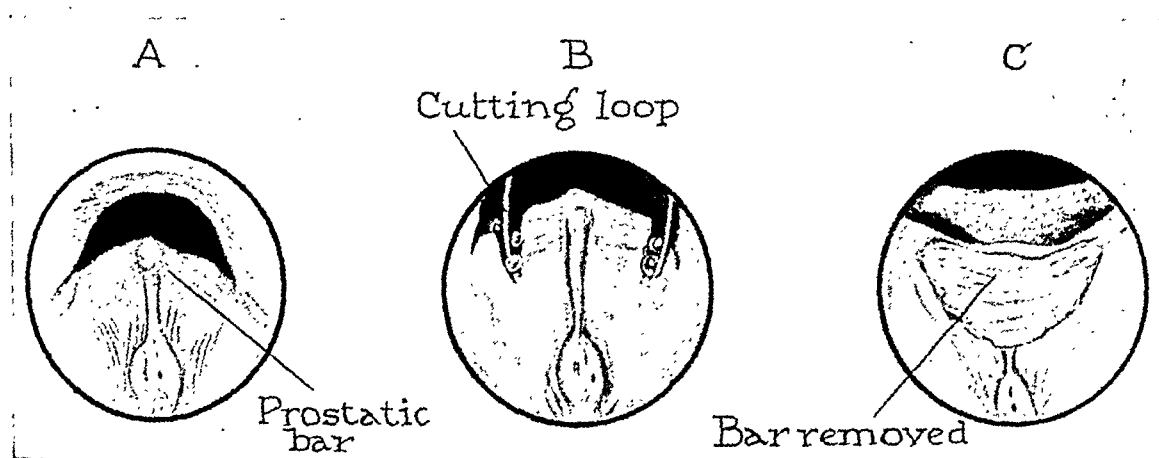


FIG. 3.—(A) Showing the presence of a bar. (B) Removal of bar. (C) The hypertrophied interureteric ligament comes into view.

MULTIPLE RESECTIONS.—Objections to this method have been made because of the fact that a second or even a third resection is necessary. This, I do not believe, is sound reasoning and requires some qualification. In this series of resections a second one was performed in 10.6 per cent of the cases, and a third one in 3.7 per cent. A study of this group shows that the cases can be divided into, and discussed under, three headings.

(1) In the cases of carcinoma a second resection is necessary when the carcinoma, because of its recurrence or continued growth after the resection, again produces obstruction. I believe that two resections for carcinoma are preferable to one suprapubic cystostomy and a permanent suprapubic drain or catheter.

(2) In this group are the patients with large benign hypertrophies in whom, it can readily be understood, the obstruction cannot be removed at one operation, because of the size of the growth. I always tell these patients that a second resection may be necessary.

(3) In the remaining cases in this group are the patients in whom not enough tissue was removed at the first resection. This occurred with some frequency in the early cases, but with experience a second resection became less and less frequently necessary.

HEMORRHAGE.—Before the technic of resection was completely mastered, hemorrhage at the time of operation was at times a serious problem, but with experience this untoward occurrence becomes less and less of a problem, although occasionally a serious hemorrhage occurs no matter how careful one may be. Careful search for the bleeding point should be made and its immediate control effected. I endeavor to have the patient return to his room with the wash water free of blood, that is, clear or faintly tinged. Each bleeding point should be isolated and fulgurated before proceeding with the resection, and, above all, blind indiscriminate coagulation is to be avoided. I believe that late secondary bleeding and the persistence of infection are due in some cases to indiscriminate widespread and deep coagulation.

Secondary bleeding occurring on the tenth to the fourteenth day was present in 19 cases but was never severe. Clots, when present, were evacuated with the Bigelow pump and the bladder washed out with a warm solution of silver nitrate. In most of the cases this controlled the bleeding, but when this procedure failed the resectoscope was introduced, and the bleeding point fulgurated or excised.

Late hemorrhage occurred in 14 cases, at periods varying from three months to two years after the resection. In the cases that I have had an occasion to reëxamine, enlarged vessels around the bladder orifice and in the prostatic urethra were found. These were destroyed by fulguration. An interesting fact is that these late hemorrhages occurred in patients with very large prostates.

In one instance in a patient aged 80, hemorrhage occurred 26 months after resection. A suprapubic cystostomy was performed (elsewhere) in order to control the bleeding. The patient was unable to withstand even this simple procedure and died.

EPIDIDYMITIS.—The incidence of epididymitis has diminished as experience with resection has grown. Of the first 117 cases 15 per cent had this complication, and a routine vasectomy was done, an operation no longer employed, as this complication is very rare.

RESULTS.—In order to determine the results obtained with resection, two methods of investigation were used: (1) In so far as it was possible, every

attempt was made to have the patients return to the office or hospital for a personal examination. (2) Many of the patients who lived out of town could not, or would not, travel to the city for personal interviews and examinations, hence it was necessary to resort to a questionnaire.

When the obstruction had been completely relieved and there were no complicating conditions present, the symptoms rapidly subsided, the pyuria disappeared, and the urine became clear. It might be well, at this time, to mention the fact that in some of the patients in whom the pyuria persisted, without symptoms and without residual urine, and in whom no local treatment was instituted, examination at the end of from three to six months



FIG. 4.—Showing a diverticulum much larger than the bladder.

showed a complete disappearance of the pyuria. In other words, in some of the cases a certain elapse of time was necessary before the urine became clear. This can readily be understood because cystoscopic examination in some of these cases still showed the presence of white sloughs at the end of 11 weeks. Aside from the slow healing in some of the cases there were other causes for the persistence of the pyuria, among which may be mentioned:

(1) *The Presence of One or More Diverticula.*—In some cases one or more diverticula were responsible for the turbid urine, although the patient was symptom free; under these circumstances it was difficult to convince the patient that a diverticulectomy should be performed in order to clear up the turbid urine (Fig. 4).

(2) *The Presence of Large Hydronephrosis*.—In some of the cases of persistent pyuria, hydronephrosis was the contributing factor; even after the prostatic obstruction had been completely relieved, the hydronephrosis and hydro-ureter persisted, with stasis and infection, and hence pyuria. This cannot be reasonably charged as a failure of resection.

(3) *Infection in the Seminal Vesicles*.—Infection in the seminal vesicles as a cause of the persistence of symptoms and turbid urine following surgical prostatectomy is recognized by all urologists, and was stressed by Boyd⁵ some years ago. If symptoms and turbid urine persist after a reasonable time and if infection is found in the seminal vesicles upon examination, then the use of heat per rectum, systematic massage, and instillations will result in completely alleviating the symptoms and clearing up the urine. It is well to bear in mind that even when the urine is clear infection in the vesicles may be the cause of symptoms.

(4) *The Formation of Stone*.—Calculus formation following resection has been rare in my experience, having occurred only four times; three in my own cases and once in a case resected elsewhere. After litholapaxy there was a complete disappearance of the pyuria and the symptoms.

(5) *Failure to Relieve the Obstruction*.—Naturally, failure to relieve the obstruction results in a continuation of the symptoms, as well as a persistence of the pyuria.

(6) *Indiscriminate, Widespread Coagulation in Controlling the Bleeding at the Time of Resection*.—This has already been considered under hemorrhage.

RESIDUAL URINE.—The objective in the treatment of the patient suffering from prostatic obstruction has, as its ultimate goal, the relief of the obstruction; whether or not this result has been attained can best be determined by the estimation of the residual urine. It is necessary to bear in mind that the amount of residual in a certain number of cases will gradually diminish. I have seen patients who, when discharged, still had an ounce or two of residual urine, and when examined six months later had only a few cubic centimeters. It is fair to assume, therefore, that in some of the patients mentioned in the table, smaller amounts of residual urine could be demonstrated if the opportunity of an examination were presented today.

I have had the opportunity of examining 273 patients for the purpose of determining the question of residual urine (Table II).

TABLE II

AMOUNTS OF RESIDUAL URINE IN 273 CASES FOLLOWING TRANSURETHRAL RESECTION

No residual urine.....	181 cases (66.30%)
10-20 cc.	44 cases (16.11%)
Total.....	(82.41%)
20-30 cc.	17 cases (6.22%)
30-40 cc.	5 cases (1.83%)
40-50 cc.	6 cases (2.19%)
50 or more cc.	20 cases (7.32%)

A detailed analysis of the 20 patients who had 50 or more cubic centimeters of residual urine is presented in Table III.

TABLE III

ANALYSIS OF CASES WITH HIGH RESIDUAL URINE

Diverticula of bladder.....	5 cases
Carcinoma of prostate.....	5 cases
Large hydronephrosis.....	2 cases
Bladder and prostatic calculi.....	2 cases
Periprostatitis.....	1 case
Second resection advised.....	2 cases
No return for check-up.....	3 cases

In some of these cases the persistence of turbid urine was due to changes which might be directly ascribed to the bladder neck obstruction and hence one cannot rightfully classify such cases as failures; for instance, in five cases the diverticulum was responsible for the persistence of turbid urine, and I am of the opinion that part of the residual urine can also be explained on this basis. In the cases of carcinoma of the prostate the carcinoma continued to grow and hence produced obstruction. In two cases the large hydronephrosis was responsible for turbid urine and a certain amount of residual. The two patients with bladder calculi were relieved of the turbidity of their urine and obstruction as previously mentioned under the subject of formation of stone following resection. In two cases sufficient tissue had obviously not been removed and the patient refused to have a further resection. And, finally, in three instances it was impossible to have the patients return for a check-up.

INCONTINENCE.—There has been no instance of complete incontinence in this series of 804 resections. Shortly after leaving the hospital a small number have had difficulty in holding urine. This was not due to incontinence, but to urgency and imperative urination. Continence was eventually recovered. In a few instances the patients would lose a few drops, but this was temporary and, as the infection cleared up, the condition rapidly disappeared. In two instances the patients' loss of a few drops was due, not to incontinence, but to stricture of the urethra.

In one instance, a recent case, lack of control was rather marked and annoying during the daytime, but at night the control was perfect. The patient was given ephedrine, and at examination, three days ago, showed great improvement.

In a second case, when last seen three months ago, the patient had perfect control at night and during the day except when he assumed certain positions, and then a few drops would escape.

URETHRAL STRICTURE.—Whether or not stricture formation will occur in a sufficiently large number of cases, to justify the statement that resection produces stricture, must be determined with the passage of time, and the same should be said regarding the question of whether or not it will occur more frequently with resection than it did with surgical prostatectomy. Doubt has recently been expressed as to whether or not resection produces a stricture,

it being the opinion of some that when stricture is found following resection the stricture was present before operation.

SEXUAL FUNCTION.—So far as the sexual function was concerned, there has been no decided change. In the majority of the cases there has been no change, whereas, in some, with an improvement in the general condition, there has been an improvement in the sexual function. In only a few cases has there been a slight impairment of function.

RECURRENCE.—A good deal of discussion has centered around the question of whether or not recurrence will take place following transurethral resection. This question cannot be definitely answered at this time. It is a well known fact that recurrences have taken place following both suprapubic and perineal prostatectomy. One of the characteristics of recurrence following surgical prostatectomy is the fact that the interval between the removal of the prostate and the development of symptoms which demand further prostatectomy averages about eleven and one-half years.⁶ It stands to reason that if recurrences are going to occur, the time since the introduction of resection has not been long enough for them to develop. On the other hand, should recurrences occur after a period of five or ten years, a second transurethral resection should be a perfectly simple procedure.

MORTALITY.—The mortality rate has fluctuated from time to time, depending in part upon the type of cases and whether or not one wishes to refuse resection to many of the so called "bad risk" cases, which I have not done. My records show that I have performed 184 resections with but one death—a mortality of .54 per cent. Recently a large number of "bad risk" cases have presented themselves and the mortality in 804 resections was 3.9 per cent.

If resection can relieve both obstruction and symptoms, and also has to its credit a shorter period of hospitalization, a lower mortality rate, and fewer postoperative complications than in the cases in which prostatectomy is performed, it obviously has merit and should find its proper place as a surgical procedure.

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DISCUSSION.—DR. EDWIN BEER (New York, N. Y.).—A certain amount of exaggeration and overenthusiasm may be necessary to call attention to, and to put over, a new surgical procedure. Whether this is due to the natural lethargy of a large part of the medical profession, I do not know. As a result of this overswing of the pendulum, at times harm is done, but this is usually only a temporary state. Eventually the pendulum swings back, a normal equilibrium is established, and the exact position of such a new procedure as Doctor Kretschmer has so clearly presented to us, is recognized. This cor-

rection of the overenthusiasm is already manifest in the literature, and before long we shall recognize clearly the possibilities of this new method of attack, and at the same time its limitations and dangers.

About 1909, Hugh Young started the transurethral removal of fibrous obstructions at the bladder neck, after the various attempts of European surgeons along these lines, during the latter half of the last century, had given way to the operation of prostatectomy. One year later the profession became acquainted with the surgical use of the high frequency current in the bladder, and its possible therapeutic value in instances of bladder papillomata, tuberculous ulcers of the bladder and prostatic adenomata. Since those days, the instrumental advances and the modalities of the currents have been much improved and modified, so that at present we have a variety of instruments for cutting out pieces of the bladder neck and of the prostate, either by punch procedures followed by cauterization, or by resectoscopes with loops of one sort or another, activated by the high frequency cutting current of such oscillations and intensity as to cut living tissue under water. These changes are in the nature of a great and fundamental advance.

The three types of cases in which these new methods are of use are as follows:

(1) Contractures of the neck, which in years past were excised by wedge excision from above through the bladder. These can be cut with a point or loop electrode with complete relief of symptoms, using an ordinary operating cystoscope or a resectoscope. This is a great improvement over the cold punch operation or the suprapubic excision. The latter procedure or approach, however, may be useful when the exact physical status of the neck of the bladder is not accurately visualized.

(2) Obstructions caused by carcinoma of the prostate also lend themselves very satisfactorily to these transurethral resections, which may be repeated as new obstructions develop. The pathologic tissue removed during these operations is often helpful in establishing the correct diagnosis.

(3) When it comes to the ordinary and usual type of prostatic hypertrophy or adenoma, the field of transurethral resections has no limitations for some enthusiasts and very definite limitations for others. In this group of patients, there is a subgroup with mild symptoms of frequency and questionable obstruction, associated with a very small amount of residual urine and a very moderately enlarged prostate, upon whom no experienced surgeon would have felt justified in performing a prostatectomy. These patients present a definite potential field for transurethral resections, and may represent a large proportion of the total in most published series of resections. The frequency, and perhaps infection, do not regularly disappear, but may be made worse following these excisions of some prostatic tissue, despite reduction of residual urine. These cases are definite beginning prostatic adenomata and have nothing to do with those cases which have been resected prophylactically before any definite complaint has developed. It is doubtful whether resection affords these patients the expected relief with any regularity. If the subjective complaints are well developed, one is justified in attempting to give relief by resection, even though it may be only temporary and incomplete. Correct diagnosis here, as always, is essential.

In addition to these mild prostatics who frequently are worse off after a resection, there are two other groups of definite prostatic adenomata that must be discussed: (a) the moderately large, bilobe, trilobe or single lobe prostate, and (b) the very large, more or less trilobe or bilobe hypertrophy. In those localities where no pressure is brought to bear upon the surgeon by competitors or by the patient or his friends, the opinion is gradually devel-

oping that the last mentioned group of very large, succulent adenomata should be treated radically and definitively by prostatectomy or enucleation of the adenomata, either by the suprapubic or the perineal approach. This attitude seems to be based on a great many factors, without denying that if the "resectionist" is patient he can whittle away a fair amount of the largest prostates in one or more sessions.

The operation of suprapubic prostatectomy in two stages has gradually assumed the status of an almost minor procedure, with a low mortality, 6 plus per cent, usually incidental to cardiovascular disturbances, and with complete cure and no chance of recurrence, if properly performed. On the other hand, the transurethral approach in these cases frequently is followed by a whole group of new complications, such as primary or secondary hemorrhage into the bladder, requiring repeated evacuation of clots, invariably causing great discomfort, infection of the bladder and the more or less completely resected prostate base, which frequently, much more frequently than is reported, may turn the scales against the patient, not to mention the various instrumental damages and perforations that are reported by competent instrumentalists. In this group of cases, the prolongation of the necessary instrumental work and the various complications are liable to have a definitely higher mortality than follows a two stage suprapubic enucleation. This is our experience, and I believe if this type of case were alone considered, the data of other clinics would probably bear me out. The trouble with most statistical studies along these lines is that the mortality statistics are grouped covering the simple cases of contracture, the small, almost symptomless hypertrophies, the prophylactic excisions, perhaps incorrectly interpreted cystoscopically, and the moderate sized but definite prostatic adenomata, as well as the large hypertrophies.

In the moderately enlarged prostates, as opposed to the very large adenomata which weigh one or more ounces and are as large as one to three or more lemons, there is a definite field of usefulness for this method, even though repeated sessions may be required before the patient can void and be comfortable, and even though one may, as time goes on, see more and more of these partially removed adenomata redevelop and produce recurring symptoms, which is a rare sequela to a properly executed, complete enucleation. There is no doubt that in this group of moderately enlarged prostates one is justified, if the patient requests it, and especially if he is a poor surgical risk owing to poor renal function, coronary disease, diabetes, and so forth, in using transurethral resection. From my experience, I find a careful follow up of these resected cases leaves much to be desired, and perhaps in view of the ease with which transurethral resections can be done, with our modern instruments, the technician is liable to be too enthusiastic, emphasizing the procedure rather than the result. Further experience will decide whether the life expectancy of resected patients is equal to, or as long as, that of patients who have had a total prostatectomy.

In traveling during the winter in the South, I have been impressed by the reports of large numbers of "resected" patients who require continued treatment, soundings and bladder irrigations, *etc.*, which practically no properly prostatectomized patient ever requires. There is no doubt that most resected cases void more readily and have much less residual than prior to operation, but large numbers are not absolutely and definitely cured, as they are after a complete enucleation of the adenoma by operation. Pyuria, frequency and dysuria often persist for months or permanently in every series in which a really careful follow up is maintained.

That transurethral resection of the prostate has become an unusually

popular procedure, without due selection of cases, cannot be denied. This is clearly evidenced by the fact that few clinics in the first 30 years of this century were able to report over 1,000 cases in whom prostatectomy had been indicated and performed, whereas in the last five years a number of clinics have reported over 500, and some even 1,000 to 2,000, cases that have been suitable for and required transurethral resection. Is the male in our race degenerating so rapidly, or is every male a potential victim of the resectionist? Even after broadening and extending the indications for treatment of prostatism by prostatic resection, it takes a lot of imagination to believe that this sudden increase in prostatitis is not a product of poor, inadequate and slipshod diagnostic investigation. Naturally it follows that in these cases, without the usual imbalance caused by real prostatic adenomata, the mortality of resection must be low, the risk being almost negligible.

We must remember that we are doctors, and not be carried away with technical performances which savor occasionally of tricks. Undoubtedly the popularization of transurethral resection has done infinite damage to patients throughout the country, to mention only the reported great increase in the sale of penis clamps for postoperative incontinence. It may take some time before the fever abates, but from an adequate, carefully studied series of cases, not running into overwhelming thousands, I feel sure that the profession will decide, much as I have done in the above few words, as to the field and scope of transurethral resection.

DR. WILLIAM E. LOWER (Cleveland, Ohio).—The procedure of transurethral resection of the bladder neck for obstruction has been revived in the last few years and, as Doctor Kretschmer has said, this is probably due to improvements in instruments and electrical apparatus. Not only are the median bars and the sclerotic obstructions resected now, but the use of transurethral resection is being extended to include a much wider field, especially in the treatment of prostatic hypertrophy.

I think one thing Doctor Kretschmer did not stress sufficiently is that transurethral resection is not a simple procedure. Technically, it is more difficult than prostatectomy and the convalescence following this operation is, in many cases, not without complications. If the operation is not well done, incontinence occurs with its associated annoyance.

In what cases should this procedure be used? Experience has taught us that its scope of usefulness is much wider than we formerly thought, but again, I want to emphasize the danger of broadcasting the simplicity of the operation. However, it is true that it carries with it a low mortality rate and, so far, the postoperative results in most cases have been very good. In approximately 500 resections which we have performed, the mortality rate has been 1.8 per cent and we have had a series of 225 cases without a death. These are not selected cases, but include those of all types, as well as many feeble and elderly persons.

I want to emphasize a few things Doctor Kretschmer pointed out. First, the shortening of the preoperative period without catheter drainage. We no longer put in a catheter or make a cystoscopic examination in these patients. If a patient comes in with a history of frequency and especially of nocturia, we plan to make a cystoscopic examination and prepare the patient for a resection. If, at the cystoscopic examination, we find that the obstruction is not suitable for resection, we treat the patient in another way. But if it is suitable for resection, we do it at the same time, thus avoiding catastrophes that sometimes follow the use of the indwelling catheter.

As we have gained wider experience, we have removed larger and larger amounts of tissue. Another advantage of this operation is that a second or

even a third operation may be performed if necessary, without any special risk.

Bleeding is becoming inconsequential. When the procedure was first used, bleeding occurred frequently, but in only one case have we had to open the bladder.

The incidence of epididymitis in the entire series is 6.8 per cent, and the average hospital stay is less than seven days; this economic factor is of considerable importance, especially in these times.

There is no doubt that this method is very practical and of far reaching importance, but its use must be limited to those who have had sufficient experience to perform it properly; otherwise, we are going to have many crippled old men and a high mortality rate from a method which, when handled properly, is an extremely valuable one.

DR. HUGH CABOT (Rochester, Minn.).—In the first place, there are various methods of whittling out the prostate through the urethra. My notion is that the instruments will probably be greatly modified. But I insist we ought to discuss the problem without prejudice. Doctor Beer has perhaps a case to prove. I think he does chiefly prostatectomy. Doctor Kretschmer has a case to prove. He does chiefly resection. I have no case to prove.

Doctor Beer refers to the unfortunate results of resection. If we would tell the truth, we could load the statistics pretty handsomely with the unfortunate results of prostatectomy. The mortality of prostatectomy, which up to the last few years was in more than half of the cases in the hands of the occasional surgeon, has never the country over been less than 20 per cent, and is not now. Prostatectomy is an operation for experts, whether you use the suprapubic, transurethral, or the perineal method. I insist that we ought to confine our discussion to the results obtained by experts, not the results obtained by people who operate upon the patient not for prostatic obstruction but for a hundred dollars. That will cause damage, and does, in every field of surgery. That is not fair to the operation.

Six years ago, more than half the patients on my surgical list were prostatectomies. I have not done a prostatectomy in three years. There have been only three or four done in the last two years at the Mayo Clinic.

The age group is interesting. One thousand nine hundred twenty-two consecutive prostatectomies, done between 1924 and 1932, showed a 5.6 per cent incidence of patients over 75 years of age. The last 700 cases, up to January 1, 1936, show 15.7 per cent of the patients over 75.

It is frequently suggested that this operation is being performed chiefly for people who do not need it. I do not think that is true. We are operating upon sicker patients and with better results.

It has been the habit at the clinic, and it is not a bad one, to keep all the tissue which the surgeons remove. About a year ago I thought it would be interesting to take a series of 1,000 cases, to give a fair average of the gross amount of prostatic tissue removed by suprapubic prostatectomy, and compare it with the gross amount removed by transurethral resection. The amounts removed by resection are approaching those removed by prostatectomy. The group at the clinic doing resections now take out almost as much tissue on the average as was taken out by prostatectomy five years ago. It thus appears the transurethral method is becoming the method of prostatectomy. If we insist upon the same amount of skill for this method as is shown by the experts using the suprapubic or the perineal route, then resection has much to offer and will cover a large portion of the field.

DR. HERMAN L. KRETSCHMER (Chicago, Ill.) closing.—I agree with

Doctor Beer that a great deal of harm is done by enthusiasts, whether they be in the field of general surgery, urology, or internal medicine. I have tried to approach the problem of transurethral resection with an open mind, without any preconceived notions, and have tried not to become hyperenthusiastic.

Just as the occasional patient may fail to receive symptomatic relief after an appendectomy, so there may be patients who do not obtain symptomatic relief, or are apparently worse, after resection. Close analysis of this group will show that the obstruction has not been completely relieved in some cases; in others, the complaints are due to an overlooked carcinoma or the presence of a diverticulum or, in a rare instance, are due to a large hydronephrosis.

Regarding the number of resections: In my experience it has been necessary in about 10 per cent of the cases to perform a second resection, and, as I mentioned in the paper, the cases in whom a second resection was necessary fall into three groups: first, the cases of very large hypertrophies in whom it is evident that a second resection was necessary to remove the obstruction; second, the cases of carcinoma that recur or that continue to grow and produce obstruction; third, the small number of cases in which not enough tissue had been taken off at the time of resection. There were five patients who required three resections each.

I agree with the statement that has been made that it is unfortunate that there has been so much sales promotion regarding various types of machine and not enough stress has been placed on thorough grounding in pathology and endoscopy of the prostatic urethra and bladder neck.

Regarding the question of incontinence, I would state that we have no patients with complete incontinence; there were two patients who had some slight trouble and they are rapidly improving.

I wish to emphasize what Doctor Lower said, namely, that this is not a simple operation and that technically it is very difficult to carry out.

Regarding the selection of cases, I have tried to emphasize in this paper that this is still a moot point for discussion. An interesting thing was noted in this series of cases, namely, that the patients who had late secondary bleeding, that is, who had bleeding two or more years after resection, were all patients who had very large hypertrophies in the beginning.

I wish to agree with the rest of the points made by Doctor Cabot and Doctor Lower and it seems to me that this procedure will take its proper place in our armamentarium in the very near future.

RELIEF OF PAIN BY PERIPHERAL NERVE BLOCK IN ARTERIAL DISEASES OF THE LOWER EXTREMITIES*

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FORTY-SIX cases of ulceration and gangrene in the lower extremities caused by occlusive arterial diseases (arteriosclerosis with and without diabetes mellitus and thrombo-angiitis obliterans) were treated by the author at the Presbyterian Hospital between 1930 and 1935, by peripheral nerve block in the lower third of the leg.

The operations were performed by exposing the nerves and blocking them with either one or a combination of the following methods: injection of alcohol and crushing, division, division and sutures, or by crushing 2 to 6 Mm. of the nerve.

The foot receives its nerve supply from the posterior tibial which supplies the skin of the sole, tarsal and metatarsal joints, skin of the plantar medial side of the great toe, and adjacent sides of the second, third, fourth and fifth toes. The sural supplies the skin of the heel, lateral side of foot and fifth toe and, occasionally, the lateral side of the fourth toe. The deep peroneal supplies the ankle joint, tarsal joints, metatarsophalangeal joints of the second, third and fourth toes, adjacent sides of the great and second toes, and the first metatarsophalangeal joint. The superficial peroneal supplies the skin over the greater part of the dorsum of the foot, lower part of the leg anteriorly and laterally, medial side of the great toe, adjacent sides of the great and second toes, skin of the medial side of the ankle and foot, contiguous sides of the third and fourth and fourth and fifth toes, lateral side of the foot and ankle, and dorsal surfaces of all toes except the lateral side of the fifth toe. Frequently some of the lateral branches are absent and their function is taken over by the sural.

The internal saphenous nerve supplies the skin of the medial ankle region and medial side of the foot as far as the ball of the great toe.

Verneuil,²⁰ in 1894, reported a case in which Quenu, in 1893, resected portions of the internal and external popliteal and internal saphenous nerves in the popliteal space because of pain from gangrene of the leg, due to exposure, in a patient 75 years old. On admission his condition of extremis prevented radical amputation. He was entirely relieved of pain by the nerve division. Chauffard described a case, reported by Quenu,¹⁴ in 1910, operated upon by Duval, in 1909, for gangrene of the great toe in which he sectioned the anterior and posterior tibial, internal saphenous and musculocutaneous

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nerves at the ankle for excruciating pain. The patient experienced immediate and complete relief.

Silbert,¹⁷ in 1922, reported three cases of thrombo-angiitis obliterans in whom he exposed the posterior tibial nerve under novocain anesthesia and injected it with absolute alcohol at the internal malleolus and obtained relief from pain in the foot.

The following are various treatments reported for the relief of pain in the lower extremities: ligation of the peripheral arteries and veins^{9, 12, 13}; periarterial sympathectomy^{2, 10, 16}; periarterial injection of alcohol^{7, 11}; dorsal and lumbar sympathectomy ganglionectomy^{1, 4}; injection with alcohol about dorsal and lumbar sympathetic ganglia^{6, 16}; intravenous injection of foreign protein^{3, 4}; intravenous injection of hypertonic (5 per cent) saline¹⁷; division of subcutaneous nerves about painful ulcerations⁵; pressure-section treatments and peripheral nerve block.^{18, 19}

Smithwick and White,¹⁸ in 1930, were the first to report a systematic technic for alcohol injection of the sensory nerves in the leg in order to render the foot insensitive. They advocated exposing the nerves low enough in the leg so that the injection did not paralyze the muscles of the leg and sufficiently proximal to the lesion to anticipate a reasonable chance of primary operative wound healing.

In 1935, the same authors¹⁹ reported 28 cases of thrombo-angiitis obliterans and 17 of arteriosclerosis with extensive obliteration of vessels, severe pain, ulceration and gangrene, in whom conservative treatment had failed and peripheral nerve block by alcohol injection was performed.

Laskey and Silbert,⁸ in 1933, recommended nerve section and suture in preference to alcohol injection because it was impossible to be sure that all of the nerve fibers came in contact with the alcohol and alcohol leaking from the nerve into the tissues might cause necrosis.

Peripheral nerve block is an anatomic operation which should not be attempted until the operator has familiarized himself with the exact local anatomy. Poor wound healing may be attributed to extensive dissection because of lack of anatomic knowledge and failure to appreciate the amount of operative trauma these tissues will tolerate. Perfection of operative technic on anatomic specimens is recommended before the operation is attempted on patients.

Procedure.—Infiltration anesthesia with one-half per cent novocain (without adrenalin) is used.

The Posterior Tibial Nerve is exposed through a 5-cm. incision 15 cm. above the internal malleolus and 2 cm. posterior to the medial tibial edge. The incision should be posterior to the internal saphenous vein. The internal saphenous nerve lies just posterior to the vein in the subcutaneous tissue and can be blocked at this time if desired. The deep fascia is incised, the septum between the flexor digitorum longus and the gastrocnemius-soleus group is followed laterally by blunt dissection to the nerve-vessel bundle which is retracted laterally, incised posteriorly and the nerve which lies posterior to the

vessel is isolated. It is freed for 1 cm., injected with 1 cc. of one per cent novocain and crushed once, twice or three times with a small hemostat, depending upon whether it is desired to obtain anesthesia of the part it supplies for six, nine or 12 months. For alcohol injection block the nerve is freed for 2 cm., silk ligatures are placed to completely encircle it, 1 cm. apart, the nerve is drawn out of its bed, saline compresses are placed behind and around it and 1 to 1½ cc. of either absolute or 85 per cent alcohol is injected into the nerve through a 26 gauge needle which is introduced on a slant, for 1 cm., into the nerve. The injected nerve becomes white and distended. The blood in the vessels of the nerve becomes brown. By means of the encircling sutures, which hold the injected alcohol between them, the nerve is rotated and injected posteriorly and medially not using more than 1½ cc. of alcohol for the complete injection. The encircling sutures are removed, the nerve is dropped back into its sheath, hemastasis is effected with five zero plain catgut, the deep fascia is not sutured and the skin is gently approximated with fine silk on sharp, small, cutting edged needles.

Such a block will produce anesthesia in the sole supplied by this nerve for six to 12 months. Crushing the nerve in the injected area will prolong the anesthesia for four to six months more. Division and suture requires an exposure of the nerve for 2 to 4 cm. Sutures of fine silk are placed before the nerve is divided and the vessel of the nerve is ligated before complete division. This type of block is a more complicated operative procedure than crushing which produces the same results without ill effects and unless there is definite indication for division and suture I prefer crushing the nerve. Nerve crushing is the simplest, quickest and least traumatizing to soft parts and is recommended as the method of choice.

The Deep and Superficial Peroneal Nerves may be blocked through the same or separate incisions. The operator should decide whether one or two incisions will be used before operating. In extremities, with severely compromised circulations, separate small incisions placed directly over each nerve are more likely to heal by primary union than a single large incision exposing both nerves, which may require a dangerous amount of retraction and subcutaneous tissue dissection. To expose the deep peroneal nerve through a single incision, the skin is incised for 3 cm., 12 cm. above the external malleolus just lateral to the tendon of the tibialis anticus muscle. To expose the deep and superficial peroneal nerves through a single incision, the skin is incised for 5 to 6 cm., 12 to 15 cm. above the external malleolus. The deep peroneal nerve lies deep to, and between the tendon of, the tibialis anticus and extensor digitorum longus muscle, anterior to the vessels, about 1 cm. below the deep fascia and it is not a large nerve. It may be posterior to the vessels. This nerve should be divided only for the relief of pain in the presence of a lesion which will not heal, and when amputation of the great or second toe is imminent. If the toe lesion is expected to heal, the nerve is blocked by crushing, alcohol injection or both.

The Superficial Peroneal Nerve is larger than the deep peroneal. A single

incision to expose it is made 2 cm. long, 8 to 10 cm. above the external malleolus midway between the tibia and fibula. It is placed sufficiently posterior to the incision exposing the deep peroneal to insure sufficient blood supply to the skin between the incisions. The nerve trunk or its two separate branches at this point should be blocked. Thin extremities are best suited to a single incision exposing both deep and superficial peroneal nerves. The incision is placed 12 to 15 cm. above the external malleolus over the extensor digitorum longus muscle and should be about 6 cm. long.

The Sural Nerve lies in the subcutaneous tissue and is exposed through a 1 cm. incision 8 cm. above the external malleolus just lateral to the tendo achillis. It lies deep to the small saphenous vein.

The toe or foot lesion is not surgically treated at the time of the nerve block. It is dealt with more radically after primary operative wound healing has occurred.

Incision should not be placed near acute pathology in the leg; in fact, such pathology contraindicates nerve block until it has subsided. Occasionally, nerves are not found in their usual anatomic position, in which case it is dangerous to perform extensive dissection looking for them. It is better to close the wound, wait for healing, and then locate the nerve by novocain injection and make the incision over this site. Unusual branching and abnormal distribution of the nerves may be encountered and should be borne in mind when a nerve is being sought for, otherwise complete anesthesia may not be obtained over the usual anatomic distribution of the nerve.

In the 46 cases of obliterative arterial diseases of the lower extremities observed, 82 nerves were blocked with alcohol; 29 with alcohol and crushing; 27 by division and three by division and suture. The following results are reported from a total of 141 blocked nerves. In this series the following is interesting. There was one female with pathologically proven thrombo-angiitis obliterans. The average age of the thrombo-angiitis obliterans group was 39 years; the arteriosclerotics with diabetes mellitus, 62 years, and the arteriosclerotics without diabetes mellitus, 66 years. The dorsalis pedis and posterior tibial arteries were not palpable in any of the cases blocked. The popliteal artery was palpable in 50 per cent of all cases blocked and the femorals were palpable in all cases. The oscillometric readings in the lower third of the leg varied from 0 to 1. The surface temperature of the toes were all two to three degrees below normal but were normal for the proximal half of the foot and lower legs. Pain was entirely relieved in 97 per cent of the thrombo-angiitis obliterans cases, in 90 per cent of the arteriosclerotics without diabetes mellitus, and 81 per cent of the arteriosclerotics with diabetes were relieved of from 75 to 90 per cent of their pain. The wound healing was primary in 91 per cent of all cases. In three of the earlier cases skin necrosis prevented complete healing for two or three months. The follow-up in the thrombo-angiitis obliterans cases has been uniformly good. The return of sensation has been preceded by paresthesia which has not been trouble-

TABLE I
THROMBO-ANGITIS OBLITERANS

Arteries										Nerve Block			Amputations							
Pt.	Unit No.	Age	Sex	DP.	PT.	P.	F.	Osc.	Post. Tib.	Ant. Tib.	Sup. Per.	Sural	Pain Relieved	Wound Healing	Cont. Gang.	Leg	Thigh	Art. Leg	Days—Block Amp.	Follow-Up
F. C.	80319	47	M.	—	—	P	P	o	A	A	A	A	100%	P	Yes	Gritti-Stokes	Yes	51	Yes	4 yrs. 334*
R. T.	288299	41	M.	—	—	P	P	2	A	AC	A	A	100%	P	Toe	Toe	Toe			2½ yrs. 444
H. B.	330722	28	F.	—	—	—	P	.5	DS	A	A	D	85%	P	3 toes	No	3 toes			3 yrs. 444
J. M.	278427	40	M.	—	—	—	P		A	A	C	A	100%	P						4½ yrs. 444
C. H.	361398	40	M.	—	—	—	P	o	A	C	C	A	75%	P						
S. F.	191402	51	M.	—	—	—	P		A	C	A	AC	80%	P	Yes	L1/3	Yes	27 mos.	Yes	2 yrs. 444
J. O.	259843	47	M.	—	—	—	P	2-2.5	A	AC	C	C	100%	P	Toe	Toe	Toe			5 yrs. 444
J. M.	356049	36	M.	—	—	—	P	.5	A	A	A	A	100%	P	No	No	Toe			3 yrs. 444
A. R.	366193	36	M.	—	—	—	P	.25	A	D	D	C	100%	P	Toe	Toe	Toe			2 yrs. 444
				—	—	—	P		(Rt) A	A	C		100%	P						
									(Rt) D-S	D	D		90%	S						Pain in anesthetic area for 6 mos.
D. S.	363519	43	M.	—	—	—	P	2-¼	(Rt) D-S	D	D	A	100%	P						Psychopathic.
												A	o%							Duod. ulcer
J. J. W.	359197	47	M.	—	—	P	P		A	A	A		100%	S	No	Lat. wd. ulcerated 5 mos. after nerve block.	Lat. Pyocyanous (in pure culture).			Culture: Pain in anesthetic area for 6 mos.
L. R.	249991	41	M.	—	—	P	P		A	AC	A	AC	50%	P	No					
A. H.	392546	25	M.	—	—	P	P	o	A		A	AC	100%	P	No					
G. H.	443751	35	M.	—	—	P	P	o	AC	AC	AC	AC	100%	P	Yes	L1/3	Yes	7 wks.	2 yrs. 444 phlebitis cont.	Ulcer on amp. stump
C. J.	44502	38	M.	—	—	P	P	o	A	A	A	A	100%	P	No					7 mos. 444
S. S.	410276	52	M.	—	—	P	P		C	C	C		100%	P	Toe	2 toes	Toe	Typhoid vaccine failed to relieve pain		3 yrs. 444
F. M.	244746	28	M.	—	—	—	P		(Lt) A	A	A	A	100%	P			Brachial pteriarial sympathectomy failed to relieve pain			2 yrs. 444

A—Alcohol injection, AC—Alcohol injection and crushing, D—Division, DS—Division and suture.

* Follow-Up, Anatomic—(A), Symptomatic (S), Economic (E), four equals 100 per cent, three equals 75 per cent, two equals 50 per cent, one equals 25 per cent of normal, so 4444 equals 100 per cent, Anatomic, Symptomatic, and Economic Follow-Up results.

PERIPHERAL NERVE BLOCK

TABLE II
ARTERIOSCLEROSIS

TABLE II ARTERIOSCLEROSIS													PERIPHERAL NERVE BLOCK									
Pt.	Unit No.	Age	Sex	Arteries				Nerve Block			Amputations			Follow-Up								
				DP.	PT.	P.	F.	Osc.	Post. Tib.	Ant. Tib.	Sup. Per.	Sural	Pain Relieved		Wound Healing	Cont. Gang.	Leg	Thigh	Art. Leg	Block Amp.		
A. O.	230891	56	M.	—	—	P	P	A	C	A	D	60%	PP	No	No	No	No	Two yrs. 322.* Died after prostatectomy 18 mos. 444				
L. B.	406170	62	M.	—	—	—	P	1/4	A-C	D	D	90%	PP	Yes	L1/3	Yes	70	2 yrs., 10 mos.				
C. W.	356223	66	M.	—	—	—	P	1/4	A	C	A-C	85%	PP	No	L1/3	Yes	11	2 yrs. 444				
J. T.	392510	69	M.	—	—	—	P	3/4	A	A	A	100%	PP	Yes	L1/3	Yes	11	2 yrs. 444				
E. O.	307215	72	M.	—	—	—	P	—	A	A	A	Amp. through thigh 2 days after nerve block and later C. Welch. P.	90% Slow	Yes	L1/3	Yes	11	2 yrs. 444				
S. R.	411423	68	M.	—	—	—	P	—	A	D	D	100%	PP	Yes	L1/3	No	40	Fractured neck of femur same side 3 yrs. 330				
L. K.	141655	58	M.	—	—	—	P	0	A	A	A	100%	PP	Yes	L1/3	Yes	150	Cardiac death 2 1/2 yrs. after block				
J. P.	369121	82	M.	—	—	—	P	0	A	D	D	100%	PP	No	L1/3	Yes	150	2 yrs. 244				
E. E.	384822	45	M.	—	—	—	P	0	A	D	D	100%	PP	Yes	L1/3	Yes	150	2 yrs. 030 Ulcer dorsum persists				
J. O.	435999	64	M.	—	—	—	P	0	A	D	A-C	100%	PP	Yes	L1/3	Yes	150	Nerve anomaly (AT)				
S. L.	300503	52	F.	—	—	P	P	0	A-C	D	A-C	100%	PP	Yes	L1/3	Yes	150	8 mos. 444				
T. T.	441848	67	M.	—	—	P	P	0	A-C	D	A-C	90%	PP	Yes	L1/3	Yes	150	Died 2 mos. after amp. bronchopneu.				
B. W.	436003	75	F.	—	—	—	P	1.5	A	A	A	90%	PP	Yes	L1/3	Yes	150	4 mos. 030				
M. H.	461345	71	M.	—	—	—	P	0	A-C	D	A-C	90%	PP	Yes	L1/3	Yes	150	8 mos. 444				
J. K.	461345	79	M.	—	—	—	P	0	A-C	D	A-C	90%	PP	Yes	L1/3	Yes	150	8 mos. 444				
J. S.	461345	79	M.	—	—	—	P	0	A-C	D	A-C	90%	PP	Yes	L1/3	Yes	150	8 mos. 444				
O. F.	470134	60	M.	—	—	—	P	0	A-C	D	A-C	90%	PP	Yes	L1/3	Yes	150	8 mos. 444				
F. R.	448400	68	F.	—	—	—	P	0	A-C	D	A-C	80%	Slow	Yes	L1/3	Yes	150	8 mos. 444				
A—Alcohol injection, AC—Alcohol injection and crushing, D—Division, S—Suture after division.																						
Arteries (—) not palpable, (P) Palpable.																						
* Follow-Up, Anatomic—(A), Symptomatic (S), Economic.																						
4444 equals 100 per cent, Anatomic, Symptomatic, Economic.																						

A—Alcohol injection, AC—Alcohol injection and crushing, D—Division, S—Suture after division.
Arteries (—) not palpable, (P) Palpable.
Nerves (A) Alcohol Injection, (C) Crush, (D) Division.
* Follow-Up, Anatomic—(A), Symptomatic, and Economic Follow-Up results.
so 444 equals 100 per cent, Anatomic, Symptomatic, and Economic Follow-Up results.

TABLE III
DIABETES MELLITUS AND ARTERIOSCLEROSIS

Arteries													Nerve Block					Amputations					Follow-Up
Pt.	Unit No.	Age	Sex	DP.	PT.	P.	F.	Osc.	Post. Tib.	Ant. Tib.	Sup. Per.	Sural	Pain Relieved	Wound Healing	Cont. Gang.	Leg	Thigh	Art. Leg	Days—Block Amp.				
H. P.	369316	59	M.	—	—	—	P.	o	AC	D	D	D	D	90%	S	Yes	L1/3	Yes	25 days	2½ yrs. 444*			
D. I.	283294	69	F.	—	—	—	P	o	A	D	D	D	D	90%	P	Yes	L1/3	Yes	34 days	2 yrs. 444. Other leg amput. 2 yrs. later patient died after this amput.			
A. C.	261072	63	M.	—	—	—	P	—	A	C	A	—	—	100%	P(2wd) S(1wd)	Yes	M1/3	Yes	32 days	5 yrs. 444. Amp. followed heat burn of external heat after block			
C. B.	250358	74	F.	—	—	P	P	—	A	A	A	—	—	60%	P	Yes	U1/3	Yes	25 days	5 yrs. 444			
M. K.	76823	56	F.	P	P	P	P	—	A	A	C	—	—	100%	P	No	—	—	—	1½ yrs. after block of B. Friedlander pneumonia			
A. R.	352879	49	M.	—	—	—	P	—	A	A	A	—	—	100%	P	No	—	—	—	1 yr. 444			
E. W.	239180	70	F.	—	—	—	P	o	AC	AC-D	D	D	D	90%	P	Yes	L1/3	No	30 days	Burned heel with external heat after block. Burns did not heal through L1/3 thigh. Second leg amput. Recovered. Pt. confined to bed and chair			
M. F.	441848	61	F.	—	—	P	P	o	AC	AC	AC	AC	AC	100%	P	Yes	L1/3	No	48 days	Amp. wd. left open, healed by granulation. 4 mos. 220			
M. W.	446317	67	F.	—	—	P	P	i	AC	—	—	—	—	50%	P	Yes	L1/3	Too soon	120 days	3 mos. 340			
E. R.	312478	71	M.	—	—	—	—	—	A	AC	C	C	C	75%	P	No	Toe	60 days	1 yr. 444				
L. L.	252371	43	M.	—	—	—	P	—	A	A	A	—	—	100%	P	Yes	M1/3 (At another hospital)	1 yr. after block.	5 mos. 440				

A—Alcohol injection, AC—Alcohol injection and crushing, D—Division.

* Follow-Up, Anatomic—(A), Symptomatic (S), Economic (E), four equals 100 per cent, three equals 75 per cent, two equals 50 per cent, one equals 25 per cent of normal, so 4444 equals 100 per cent, Anatomic, Symptomatic, and Economic Follow-Up results.

some. The foot has remained somewhat warmer and the local lesions have healed or else toe amputation sites in the anesthetized foot have healed. In three cases blocks of the same nerves have been performed three times for a recurrent painful toe ulceration over a five year period. In the arteriosclerotic cases, without diabetes mellitus, healing of the toe lesion did not occur in 50 per cent of the cases and the block was followed in two to four weeks by amputation through the junction of the middle and lower third of the leg by a modified guillotine technic.²¹ The results in the arteriosclerotic group with diabetes mellitus was the poorest of either group and more amputations followed in these cases.

TABLE IV
AMPUTATIONS IN 46 CASES OF PERIPHERAL NERVE BLOCK

	No. Cases	Leg	Thigh	Gritti- Stokes	Toes	No Amputation	Number Wounds Healing by	
							Primary	Secondary Union
Thrombo- angiitis Obliterans	17	2	0	1	5	9	51	3
Arterio- sclerosis without Diabetes	18	7	1	0	3	8	52	3
Arterio- sclerosis with Diabetes	11	8	2	1	1	1	31	3
Totals	46	17	3	2	9	18	134	9

22 of 46 cases or 48% had a major amputation.
9 of 46 cases or 19% had a toe amputation.
18 of 46 cases or 39% had no amputation.

In the thrombo-angiitis group there were three major amputations, two through the lower leg and one Gritti-Stokes.
In the arteriosclerotic group without diabetes there were eight major amputations, seven were through the lower leg and one through the thigh.
In the arteriosclerotic group with diabetes there were ten major amputations of which eight were through the lower leg and two were through the thigh.

CONCLUSIONS

The chief indication for peripheral nerve block is to relieve pain. It is a palliative operation. It saved 50 per cent of the arteriosclerosis cases and 20 per cent of the arteriosclerotics with diabetes from a major amputation. No leg amputations were performed in the thrombo-angiitis group. The release of vasoconstriction by block increased the local temperature in the anesthetized area to varying degrees in the thrombo-angiitis cases, depending upon the degree of arterial occlusion and spasm in the vessel wall. It made dressings, treatments, postural exercises, warm whirlpool baths, dakinization,

excision of sloughs and osteomyelitic sequestra and drainage of local abscesses, possible without subjecting the patient to multiple general anesthetics.

Careful instruction is necessary concerning foot hygiene and properly fitting shoes with corrected weight bearing to prevent trophic ulceration in the insensitive member. Patients should be particularly warned not to expose the insensitive part to any form of heat. Nerve block has permitted recovery with fewer major amputations and made it possible to perform minor ones where major ones might primarily have been indicated. The relief of pain during wound healing has freed patients from sedatives, improved their appetites, increased their weight and permitted normal function of their gastro-intestinal and genito-urinary tracts which were interfered with by sedatives. Restful sleep has improved cerebral disorientation. Paralysis of the intrinsic muscles of the foot which follows any type of nerve block has not interfered with normal locomotion.

These observations are in accord with many of those of previous essayists. For restatements I am apologetic but they are made to emphasize important points of technic and treatment and serve to verify other previously reported experiences.

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DISCUSSION.—DR. GRANT P. PENNOYER (New York) stated that in the vascular clinic at Roosevelt Hospital experience with the procedure described by Doctor Smith had been sufficient to be convincing that in a certain very limited number of cases the procedure is extremely valuable. Before it is attempted, however, the indications must be considered very carefully. The case should be one suffering very severe pain from a foot lesion requiring conservative treatment over a long period of time. Quite a few patients with peripheral vascular disease fall in this group. Opiates with their depressing effect on the aged are avoided. The freedom from pain greatly improves the general condition of the patient. Minor operations such as a separation of sloughs and incisions for drainage can be performed without any anesthesia. The operation is not technically difficult and the results are very satisfactory.

Doctor Pennoyer cited five cases in which peripheral nerve sections had been performed for the relief of pain in the foot, which, he admitted, was a very limited series upon which to base any conclusions. In one case the operation was only a partial success, the patient's pain not being entirely relieved. The reason for this might have been some anatomic anomaly of the peripheral nerves or a technical error in identifying them. In the other four cases, however, the relief of pain was complete. Two of these patients had arteriosclerotic gangrene which slowly progressed so that they later required amputation, but they both had a considerable period, one of about six weeks and the other four, before amputation was performed, during which they were quite comfortable. Before the nerve section they both had so much pain that it could be only partially controlled by morphine. The other two cases both have their feet, except for the loss of toes. One of these was an old gentleman with an arteriosclerotic gangrene of his right great toe who later developed an osteomyelitis of the first metatarsal. It seemed as though he was going to lose his foot but he was made entirely comfortable by blocking the nerves, and with conservative treatment for four months lost only his great toe and the distal half of the first metatarsal.

An interesting anatomic sidelight in these cases is the fact that formerly

it was taught in the Anatomy Department of Columbia University that the intrinsic muscles of the sole of the foot are very important in balancing when standing on one foot. It has now been noted that despite the fact that these muscles are necessarily completely paralyzed when the posterior tibial nerve is divided, these people seem to be able to walk and balance themselves on one foot about as well as they could before.

At Roosevelt Hospital they acutally divided the nerves instead of crushing them or injecting them with alcohol.

DR. DAVID C. BULL (New York) heartily endorsed Doctor Smith's description of the results of this procedure, namely, relief of pain, decrease in morphine required, *etc.* He called attention to a complication which might be overlooked in thrombo-angiitis obliterans, but which had occurred in one of his cases. The small wound that had been made for the peroneal nerve approach healed primarily within a week. The patient went home soon afterward, only to return several weeks later with a spreading ulcer originating in the wound. On culture this yielded a pure growth of *Bacillus emphysematosis*. The lesion cleared up with wet dressings and skin graft, and healed completely.

NERVE INJURY IN FRACTURE OF THE PELVIS

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DURING a recent one year period, 18 patients with fracture of the pelvis were treated in the Henry Ford Hospital. Six of these presented definite evidence of nerve injury. While the complaints and symptoms were not serious, in terms of life and death or ultimate function, the nerve damage caused such severe neuralgia in four of these cases that the neurologic complication became the chief complaint throughout the period of hospitalization. This experience prompted our study of 100 consecutive cases of fracture of the pelvis with special reference to nerve injury, and a review of the literature on the subject.

The standard text-books mention the complication briefly or not at all. Scudder²⁴ states that G. G. Davis observed nerve injury in 2 per cent of pelvic fractures, and that the trauma to the nerve is in the origin of the lumbosacral cord as it lies at the pelvic brim. It is also stated that the evidence of nerve damage appears immediately, and that the likelihood of recovery from peroneal palsy incurred in this way is not great. Wilson and Cochrane²⁷ do not mention the complication. Speed²⁵ says, "Nerve injury to the sacral plexus is rare, unless there is a severe crushing injury of the sacrum." Under the caption "Rare Complications of Fractures of the Pelvis," Key and Conwell²³ state that paralysis of the sciatic nerve occasionally occurs in fractures of the posterior pelvic ring. The paralysis is usually temporary and clears up spontaneously. Paralysis of the obturator nerve is a rare complication of fractures of the anterior pelvic ring.

A review of the English and German literature of the past 20 years revealed no paper dealing particularly with this complication. No attempt was made to review the entire literature on fractures of the pelvis, a considerable part of which deals especially with urinary tract injury, and methods of treatment of the fracture. However, a fair idea of the frequency of nerve injury was obtained by reading all the articles containing reports of series of cases, and others in which nerve injury might have been mentioned. One thousand eight hundred eighty-nine cases of fracture of the pelvis were collected, and in this group, 14 cases of nerve damage were mentioned, giving an incidence of 0.75 per cent for the complication. The sources of this material are given chronologically in the bibliographic table appended.

Most of these writers make no mention of nerve injury. Caldwell² stated that trauma to the various nerves in the vicinity of the pelvis may occur, but he reported no cases. Bacon had one case of persistent sciatica in a series of 32 cases of fracture. This patient had a fracture of the left ischium with moderate displacement. The nerve symptoms were late in appearing, and

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prolonged the disability to six months. Hirsch²² observed nerve irritation in his series of 102 cases of pelvic fracture, but the incidence was not stated. He was of the opinion that injuries to the nerve plexus, as demonstrated by disturbance of reflexes, motor function, and sensation, occur most often in injury of the posterior ring of the pelvis. Usually the injury is a spontaneously reparable one, consisting of a tearing, contusion, or hemorrhage into the nerve, and the symptoms subside quickly, with reflexes frequently remaining absent permanently. He did not observe peroneal paralysis.

Among Orator's⁵ 61 cases, there were three cases with nerve damage. One case, with fracture involving both sacro-iliac joints, had neuritis and knee contracture which cleared up a year later. Another patient, with a fracture through the left sacro-iliac joint, had paralysis and sensory changes in the extremity 16 years later, and was lame and bed ridden. A third case had a fracture of the left side of the sacrum and complained of sciatica. Gunzer⁷ observed two cases of complete sciatic paralysis in his 24 cases. One of these had a Malgaigne fracture, and the other an acetabular fracture. Westerborn⁸ noted permanent peroneal paralysis in one case of his series of 306 cases of pelvic fracture, a vertical fracture of the sacrum being present. Sever⁹ had one case of fracture into the right sacro-iliac joint, with complete paralysis, sensory and motor, of the right leg. A year later, the patient was well, except for slight weakness of the toes.

G. E. Wilson²⁸ reported that injury to the sacral plexus is a rare complication of fracture of the pelvis. He had seen only one case. The damage to the pelvis was severe, the right pubic bone having been driven downward two inches, with one-half inch displacement of the ilium on the sacrum on the left side. There was complete left peroneal paralysis, and partial paralysis on the right. There were no sensory disturbances, and the end-result was not stated. In their series, Colp and Findlay¹² observed traumatic neuritis in one case, with fracture of the acetabulum. They assumed that there had been a laceration of the sciatic nerve, and attributed a poor end-result to the nerve injury, with the resultant atrophy of muscles, weakness, and continued pain.

Three cases of peroneal nerve injury were noted by Noland and Conwell¹³ in 125 cases. One of these showed permanent disability. Peabody¹⁴ studied eight cases of innominate luxation, and observed sciatica in only one, which case also had a fracture of the transverse process of the fifth lumbar vertebra, in addition to the sacro-iliac dislocation. Wheeler²⁶ stated, "It is obvious that the lumbosacral cord may be involved in any fracture in the region of the sacro-iliac joint, or the sciatic nerve may be stretched or crushed, giving rise to prolonged and protracted neuralgia." He did not report specific cases.

From a consideration of the above reports, one would conclude that nerve injury is comparatively rare and is to be encountered only in cases with demonstrable injury in the region of the sacro-iliac joint. Injury has been reported only in the sciatic nerve or its peroneal component. The following

nine cases of nerve injury found in 100 pelvic fractures are at variance with the above, because six of them did not present roentgenologic evidence of injury to the posterior ring, although the probability of temporary sacro-iliac separation with spontaneous reduction is admitted. Furthermore, nerves other than the sciatic were involved.

The 100 cases of fracture of the pelvis reviewed in this study were treated during the past ten years. The mortality was 12 per cent. as compared with a mortality of 8.8 per cent in 1,142 cases collected from the literature. There were five ruptures of the bladder and four lacerations of the urethra, or an incidence of urinary tract damage of 9 per cent, as compared with 11 per cent in 1,468 collected cases. The figures on nerve damage, however, differ widely from those obtained from the 1,889 cases reviewed in the literature, the complication occurring in 9 per cent of this series and only 0.75 per cent in the collected cases.

PROTOCOLS OF NINE CASES WITH NERVE INJURY

Case 1.—No. 52539. White male, age 26. Admitted October 24, 1930, after an industrial accident. Roentgenologic examination of the pelvis showed fractures through the superior and inferior rami of the left pubis, and a fracture into the left sacro-iliac joint, with slight separation. There was no evidence of nerve damage on admission. On January 27, 1931, weakness of flexion of the great toe was noted. On February 24, 1931, the patient complained of pain along the course of the sciatic nerve. Sensation was normal. On May 28, 1931, neurologic examination by Dr. G. O. Grain showed slight weakness of the tibialis anticus muscle, the calf muscles, the flexors of the toes, and the peronei. There was absolute anesthesia of the dorsum of the foot and the anterior surface of the leg about two inches above and below the ankle joint. His impression was that this represented residuals of injury to the left lumbosacral plexus. Neurologic examination on August 9, 1931, revealed slight improvement. One year later, the patient made an attempt to go back to work, but was unable to continue. On March 20, 1933, his permanent disability was estimated to be 20 per cent. A year later, he was still complaining of pain in the left foot, and some residual muscular weakness. There was no further follow-up.

Case 2.—No. 177623. White male, age 27. Admitted June 20, 1932, after an industrial accident. Roentgenologic examination of the pelvis showed a fracture of the left side of the sacrum, two fractures of the left ascending ramus of the pubis, and a fracture of the left descending ramus, with considerable separation. He was placed in a pelvic sling, and remained in the hospital 16 weeks. On September 28, 1932, he attempted to walk, but complained of weakness in the left hip and numbness of the left buttock. Neurologic examination showed an area of absolute anesthesia on the left buttock, with muscular weakness not definite at that time. Examination several days later revealed marked weakness of the gluteus medius and slight weakness of the tensor fascia femoris and gluteus minimus on the left. This was assumed to be due to injury to the left sacral plexus, involving the components of the superior gluteal nerve and the cutaneous branches of the first three sacral roots. A hip spica was applied to maintain the hip in abduction. Improvement of the gluteus medius weakness was noted on February 21, 1933, and again on June 16, 1933. On November 24, 1933, it was thought that there had been 100 per cent recovery from the nerve damage, and the patient was working. However, he reappeared February 22, 1936, complaining of some weakness of the left thigh. Slight atrophy was noted, and it was thought that there were some residuals of nerve damage.

Case 3.—No. 153883. White female, age 46. Admitted September 22, 1930, after

an automobile accident, having been treated for several days elsewhere. Roentgenologic examination of the pelvis showed fracture of the superior and inferior rami of the left pubis. An important finding on admission was a severe third degree hot water bottle burn on the lateral aspect of the right thigh, which was infected. The patient stated that the area was numb following the accident, which accounted for her not feeling the overheated bottle. The anesthetized area was in the distribution of the lateral cutaneous femoral nerve. She died suddenly five days after admission, with cyanosis and symptoms of respiratory embarrassment; clinically the cause of death was pulmonary embolism.

Case 4.—No. 211733. White female, age 39. Admitted February 2, 1935, following an automobile accident. There were fractures of the superior and inferior rami of the right pubis, with slight displacement. The patient was treated on a Bradford frame. There were no particular complaints until April 16, 1935, when she was unable to sleep on account of shooting pains in both legs. The pain arose from the low back region and radiated down the posterior aspects of the thighs and legs. Neurologic examination by Doctor Grain two days later revealed absolute anesthesia in the distribution of both lateral cutaneous femoral nerves. That night, the patient filled a hot water bottle herself, and applied it to the right thigh, receiving a third degree burn, slightly smaller than the area of the bottle. After several attempts with Reverdin grafts, the skin defect was closed. The neurologic lesion indirectly prolonged the disability several months.

Case 5.—No. 218804. White female, age 23. Admitted June 22, 1935, following a motor car accident. There were fractures of both rami of the pubis bilaterally, and evidence of bladder damage. She was put on a frame, and suprapubic cystotomy was performed for the ruptured bladder. Four weeks after admission, she complained of pain in the right leg. Neurologic examination showed slight weakness of the extensors of the toes and tenderness of the peroneal and sciatic nerves. The Achilles tendon and the sole of the foot were tender. The knee jerk and ankle jerk was diminished. The symptoms were thought to be due to residuals of mild traumatic sciatic neuritis. There were no further complaints, and the patient was discharged after eight weeks, the suprapubic fistula being closed.

Case 6.—No. 224161. White female, age 28. Admitted October 6, 1935, after an automobile accident. There was a fracture of the superior ramus of the right pubis, without displacement. She was placed on a frame. Preliminary neurologic examination was negative. Two days later, she complained of numbness of the lateral aspect of the right leg. No motor weakness could be made out. On October 23, 1935, she complained bitterly of pain in the leg. Neurologic examination showed no anesthesia of the skin. Slight weakness of the tibialis anticus, tibialis posticus, the peronei, and extensors of the toes was noted; obviously there was partial peroneal paralysis. During the rest of the period of hospitalization, she required constant sedation for the burning pain along the distribution of the peroneal nerve. She was discharged after six weeks, and returned for one follow-up visit a week later, still complaining of a burning sensation in the first and second toes. She was not followed further.

Case 7.—No. 205402. White male, age 39. Admitted January 8, 1936, several days after an automobile accident. There were fractures of the rami of the pubis on both sides, with slight displacement. Bradford frame treatment was instituted. No nerve injury was noted on admission. One day later, it was noted that there were vague sensory changes in the left lower extremity. Neurologic examination the following day showed weakness of the left tibialis anticus muscle, with foot drop. Sensory disturbance was not marked, there being only relative diminution of sensation for touch, pain, and temperature. This represented involvement of the peroneal nerve. The foot drop was still present on January 24, 1936. The patient was discharged in six weeks with no complaints, and on the first follow-up visit a week later, the peroneal palsy had entirely cleared up.

Case 8.—No. 228650. White female, age 22. Admitted January 10, 1936, after an automobile accident. Roentgenologic examination of the pelvis revealed a fracture of the body of the right pubis, and the inferior ramus of the left pubis, with negligible dis-

placement. She was placed on a Bradford frame. Ten days after admission, she complained of numbness over the posterior aspect of the left thigh, calf, sole, and dorsum of the left foot. There was no definite anesthesia or motor weakness. The left ankle jerk was weak. On February 5, 1936, she complained bitterly of burning of the sole of the foot, and was frequently in tears from the discomfort, and a neurosurgical consultant suggested subarachnoid injection of alcohol for palliation. The patient refused this procedure, but continued to require large amounts of sedatives. She was discharged after six weeks, still complaining of the burning sensation across the sole of the foot. She did not return for follow-up.

Case 9.—No. 236677. White female, age 26. Admitted February 18, 1936, following an automobile accident. There were fractures of the rami of the pubis on both sides, fracture of the left ilium into the sacro-iliac joint, with considerable overriding of the anterior fragments. She was put on a Bradford frame with ten pounds of lateral traction applied to each hip, accomplished by the use of bilateral leg encasements tied together at the feet, and the traction attached to slings around each thigh. The contraction of the pelvis was satisfactorily corrected, but the plaster encasements were removed early on account of the complaint of pain in the right leg. On March 6, 1936, an area of almost total anesthesia was noted on the anterolateral aspect of the middle of the right thigh. Subsequently, she complained of a burning pain in the ball of the right foot. Diagnosis of traumatic peripheral neuritis was made, the lateral cutaneous femoral nerve being chiefly involved. On March 21, 1936, neurologic check showed a patch of anesthesia on the dorsum of the foot corresponding to the distribution of the superficial peroneal nerve. There was slight weakness of the peroneal muscles. The patient was allowed to be up in eight weeks, and when last seen, was walking with only a slight limp. Sensation was returning to the anesthetic areas, there was no peroneal weakness, and no complaint of neuralgia. It should be noted that the nerve damage was on the right, while the sacro-iliac injury was on the left.

SUMMARY.—The nerves involved in the nine cases cited consisted of injury to the peroneal component of the sciatic nerve in six instances, the lateral cutaneous femoral three times (bilateral in one case), the superior gluteal once, and the posterior branches of the first three sacral nerves once.

The treatment of the nerve symptoms with regard to sensory disturbance was purely symptomatic, and in several cases was unsatisfactory. Several patients appreciated heat in the form of baking or diathermy; others declared that heat aggravated the symptoms, and preferred a cradle over the leg so that the bed clothes did not touch the skin. Subarachnoid injection of alcohol was probably indicated in at least one case, but was not carried out. The lesson to be learned from the two patients with severe hot water bottle burns is evident. The muscle palsies were treated by the usual methods of support until regeneration had occurred.

Since no autopsies or operative procedures were performed upon these cases, there is nothing to add to the theories of pathogenesis of the nerve injuries. The preponderance of sensory over motor disturbance, the tardy appearance of the symptoms, and the spontaneous regeneration, would support the idea of previous writers, namely, that the trauma is in the form of a stretching or contusion, rather than a laceration.

CONCLUSIONS

(1) Nerve injury in fracture of the pelvis is probably more common than is generally recognized.

(2) Such injury may occur in the absence of demonstrable damage to the posterior pelvic ring.

(3) Nerves emerging from the pelvis anteriorly, such as the lateral cutaneous femoral, may be involved, as well as the sciatic.

(4) The protracted neuralgia and muscle weakness may be the chief concern of both the patient and the surgeon in certain pelvic fractures.

The author is indebted to Dr. C. L. Mitchell for permission to publish the case reports.

BIBLIOGRAPHIC TABLE SHOWING INCIDENCE OF NERVE INJURY IN REPORTED SERIES OF CASES

	Total Cases	Nerve Injury
¹ Quain, E. P.: Rupture of Bladder Associated with Fracture of the Pelvis. <i>Surg., Gynec., and Obst.</i> , 23, 55, 1916	127	0
² Caldwell, C. E.: Fractures of the Pelvis and Their Complications. <i>Ohio State Med. Jour.</i> , 15, 798, 1919	1	0
³ Ryan, W. J.: Fractures of the Pelvis. <i>ANNALS OF SURGERY</i> , 71, 347, 1920	21	0
⁴ Forsee, G. G.: Clinical Observations on Pelvic Fractures. <i>Am. Jour. Surg.</i> , 38, 145, 1924	6	0
⁵ Orator, V.: Dauergebnisse bei Beckenfrakturen. <i>Arch. f. klin. Chir.</i> , 124, 387, 1924	61	3
⁶ Watts, W. B.: An Analysis of 48 Cases of Pelvic Fracture. <i>Southwestern Med.</i> , 9, 293, 1925	46	1
⁷ Gunzer, H.: Über Beckenfrakturen. <i>Beitr. z. klin. Chir.</i> , 133, 617, 1925	24	2
⁸ Westerborn, A.: Beiträge zur Kenntnis der Beckenbrüche und Beckenluxationen. <i>Acta Chir. Scandinav. (Supp. 8)</i> , 63, 7, 1928	306	2
⁹ Sever, J. W.: Fractures of the Pelvis. <i>New England Jour. Med.</i> , 199, 16, 1928	51	1
¹⁰ Boorstein, S.: Fractures of the True Pelvic Ring. <i>Am. Jour. Surg.</i> , 7, 633, 1929	100	0
¹¹ Harding, M. C.: Fractures of the Pelvis. <i>California and West. Med.</i> , 31, 320, 1929	127	0
¹² Colp, R., and Findlay, R. T.: Fractures of the Pelvis. <i>Surg., Gynec. and Obst.</i> , 44, 847, 1929	35	0
¹³ Noland, L., and Conwell, H.: Acute Fractures of the Pelvis. <i>J.A.M.A.</i> , 94, 174, 1930	125	3
¹⁴ Peabody, C. W.: Disruption of the Pelvis with Luxation of the Innominate Bone. <i>Arch. Surg.</i> , 21, 971, 1930	8	1
¹⁵ McNeely, R. W., and Willems, J. D.: Fractures of the Pelvis. <i>Am. Jour. Surg.</i> , 8, 573, 1930	33	0
¹⁶ Todd, M. H.: Fractures of the Pelvis. <i>Virginia Med. Monthly</i> , 14, 29, 1931	47	0
¹⁷ Parker, O. W.: Fractures of the Pelvis. <i>Minnesota Med.</i> , 14, 29, 1931	19	1
¹⁸ Magnus, C.: Über Beckenbrüche, Behandlung und Resultate. <i>Arch. f. klin. Chir.</i> , 167, 667, 1931	587	0
¹⁹ Coray, Q. B.: Fractures of the Pelvis. <i>California and West. Med.</i> , 36, 392, 1932	5	0
²⁰ Leadbetter, G. W.: Fractures of the Pelvis. <i>South. Med. Jour.</i> , 25, 742, 1933	100	0
²¹ Noland, L., and Conwell, H.: Fracture of the Pelvis. <i>Surg., Gynec., and Obst.</i> , 56, 522, 1933	60	0
Totals	1,889	14

NERVE INJURY IN FRACTURED PELVES

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THE INFLUENCE OF HEREDITY IN CANCER*

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FROM earliest times there must have been thought and speculation in regard to the effects of heredity on human life. Biblical history states that all Israel was reckoned by genealogies.¹ Heredity plays an important rôle in the size of individuals, their physical shape or habitus, muscular strength, color of the hair and eyes and in many other characteristics. It is only a short step farther to the realization that a definite tendency to disease is also transmitted in certain families. Hemophilia, diabetes and cardiovascular disease illustrate this and there are many others.^{2, 3}

The question of an hereditary tendency in cancer patients has evoked much discussion. According to Kurbler,⁴ Paget (1857) found such a taint in 22 per cent of 254 cancer patients, but Winiwarter (1878), in 548 cancer patients in Billroth's clinic, found it in only 1 per cent. Siegrist gives 2.5 per cent and Baker (1866) as high as 43 per cent. Most of these observations were from the figures of insurance companies and obviously the conclusions are not to be considered reliable. The differences are too great. As recently as 1908 Bashford⁵ made a statistical analysis of the records of the Imperial Cancer Research Fund and concluded that cancer is probably always acquired. Until our records for many generations are more perfect than at present, the statistical approach to this problem will be suggestive only.

In an analysis of family histories at the Eugenics Record office of the Carnegie Institution of Washington, Little⁶ shows that the progeny of a cancerous mother and noncancerous father were found to contain an excess of cancer. His study "seemed to show beyond any question that heredity plays a rôle in determining cancer incidence in man."

Wells⁷ states that it seems safe to maintain that the existence of an hereditary influence on the susceptibility and resistance to cancer has been established for both man and animals. Maud Slye⁸ also believes this to be the fact and suggests that cancer susceptibility behaves like a recessive, insusceptibility like a dominant characteristic. Macklin,⁹ using a different statistical approach, very logically shows that the family in which a mother and three daughters had their breasts removed for cancers before the age of 21 years had a 100 per cent incidence of the cancer, while the figures for 1928 in Canada for cancer of the breast at that age show the normal incidence would be 1 in 1,090,000. She feels that there are numerous families in which the incidence of cancer is so high that it precludes any explanation that it is by chance alone that these persons were affected. History and medical literature are full of strikingly similar instances.

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Cancer is said to have been frequent in the family of Napoleon. Napoleon himself, his father, his brother and two sisters were all victims of cancer. Warthin's family S shows 38 members dying of cancer through four generations. Finney¹⁰ reports a family in which the mother, four daughters and three nieces have all been operated upon for cancer. All but one had cancer of the breast. Three of the daughters had a second cancer in the other breast, and one of these had a third cancer in the stomach. There are, however, 37 other members of the present adult generation of sisters, brothers and cousins who are free from cancer. The proportion of diseased individuals and the location of the cancer seem to remove the element of chance. Kurbler⁴ describes a cancer family. In the second generation, one woman and two men died of cancer of the stomach. One woman also died of uterine and one woman of hepatic cancer. A son of the woman who had gastric cancer died of cancer of the rectum and all three daughters of the cancer of the liver case had cancer of the breast. In the fourth generation, there were also two women with cancer of the breast. The author recently removed the breast of a woman 38 years old. Her sister had had a radical mastectomy at the age of 36, followed a year later by removal of the other breast, and died of cancer six months later, at the age of 38. Pack¹¹ cites two brothers age 52 and 54 who were both in the hospital at the same time with adenocarcinoma of the stomach. One came in for tumor and pain, while the other showed loss of weight only. A roentgenologic study demonstrated the growth in both cases. Very convincing evidence is submitted by McFarland and Meade,¹² who feel that the simultaneous occurrence of similar, symmetrical tumors in both of homologous twins tends to prove the genetic origin of such tumors. They have collected a series of 40 tumors occurring symmetrically and simultaneously in 20 pairs of monozygotic twins. These were equally divided between benign and malignant growths. These authors¹³ describe carcinomata of the stomach occurring simultaneously in uniovular twins, who were 70 years old. Their symptoms were identical, and the tumors were symmetrically located in the stomach. There was rapid progression of the disease and a similar pathologic report. Both tumors were adenocarcinomata of the cardia and fundus which extended nearly to the pylorus. The symptoms started in October, 1933, in one, and in November, 1933, in the other. One died on April 29, 1934, and the other on June 17, 1934. Croon¹⁴ described adenocarcinomata of the uterus in twins who were both 50 years of age.

Deelman,¹⁵ after an investigation of the family history of 350 cases of cancer and 250 control cases, concludes:

- (1) "In a series of families of cancer patients, cancer is more frequent than in any other series of families.
- (2) "The surplus of cancer in the family of cancer patients always accumulates in certain distinct families.
- (3) "There is a large group of cancer patients in whose family cancer

absolutely is not more frequent than agrees with the 'normal' chance of dying from cancer.

(4) "Hereditary influences are only evident in a small category of cancer cases."

Hunter,¹⁶ using more modern statistics from insurance company records, draws the same conclusions as Deelman but states them differently. He says, "There are undoubtedly families which show a strong predisposition to the disease (cancer), but these are rare in proportion to the total population. So far there has been no conclusive proof that a person with one death in a family, either a parent or brother or sister, need fear a predisposition to the disease." It has been generally accepted that mice transmit all the Mendelian factors necessary for susceptibility to transplanted tumors and also that hereditary factors determine the characteristics of both the host and the tumor cell.¹⁷ Macklin¹⁸ has summarized the subject very well and concludes in part that:

(1) "Cancer is due to an inherited factor.

(2) "Cancer of a specific type, in a specific organ, at a specific age, tends to occur in families.

(3) "Related persons were affected ten times as often as unrelated persons.

(4) "Chronic irritation, when present, appears to accentuate the speed of a reaction which was destined to occur at a later date.

(5) "Identical twins, who have the same type of tumor, in the same organ and frequently at the same age, afford excellent proof of the rôle which inheritance plays in the production of cancer.

(6) "Belief in the inheritance of cancer affords an opportunity for early diagnosis."

She analyzed the life history of a family, later described, in which the mother, three daughters and a son all died of carcinoma of the rectum. Using the 1931 vital statistics for Canada, she found "123 deaths from rectal cancer between the ages of 30 and 55, the ages in which your group died. There were 104,517 deaths that year from all causes, at all ages. Therefore, approximately one in every 750 persons was dying from rectal cancer at those ages. Now, if cancer were due to chance, the chances for rectal cancer affecting five persons in the same family between the ages of 30 and 55 would be determined by the binomial theorem, as follows: $(a + 750b)^5$.⁵ If that is expanded, you find that in 237,304,687,500,000 families of five persons, you will get one family where all died of rectal cancer without there being any necessity for heredity being brought in as the explanation. If heredity is the explanation, and if it were due to a dominant factor, then, with a mother showing it and a family of four children, you would find the chances for all four affected varying from one in one, if the mother were homozygous for rectal cancer, to one in 16, if she were heterozygous. The chances would be also one in 16 for all children affected, if cancer were due to a recessive, for in this family, the mother would show it and the father would be hetero-

zygous for it, and the results would be the same as if it were due to a dominant with the mother having one factor for it, in other words, heterozygous." Maud Slye was recently quoted as having stated that, in her opinion, cancer could be conquered only by breeding it out of the race. She estimated it would take 500 years to accomplish this.

ABRIDGED HISTORIES OF A FAMILY PERSONALLY OBSERVED

Case Reports.—The mother, Sophie R., in 1916, at the age of 54 complained of frequent, small, lumpy stools and a sensation of pressure in the rectum and back. Examination showed a small cauliflower growth at the lower end of the rectum. A colostomy was performed but death ensued on June 11, 1916. A microscopic examination was not obtained.

A daughter, Sophie R., age 24 began in 1913 to lose weight and complain of frequent bowel movements accompanied by a griping pain in the region of the transverse colon. She also noted blood in the stool. In June, 1914, an appendicostomy was performed with plication of an incompetent ileocecal valve. She gained weight and the diarrhea was controlled, but traces of blood were still present. A tuberculin test was positive. In September, 1914, a rectovaginal fistula developed and a large nodular mass was felt in the lower rectum. A microscopic examination showed a malignant adenoma. Radium was used but death ensued on March 30, 1916, at the age of 30 years.

A daughter, Bertha R., age 25, noted a mass the size of a grapefruit in her abdomen. On June 3, 1915, the terminal ileum, cecum and a retroperitoneal fibroma were removed. In June, 1931, she reported that for several months she had noticed a slight change in her bowel action. First there was a diarrhea and now for two weeks there have been gas and distension. Her age is now 40. Examination showed a hard distended abdomen and a circular cauliflower mass, admitting only the tip of the index finger, was felt three inches up the rectum. A colostomy was performed. Microscopic examination of the growth showed an adenocarcinoma. Death occurred on the day following operation.

A son, William R., age 31, in October, 1930, stated that six months previously he had suffered from several attacks of indigestion accompanied by chest pain and gas in the stomach. One month later looseness of the bowels ensued and pain in the left loin with much intestinal gas. Examination showed a large nodular growth of the rectum forming a complete circle. There were also metastases in the lung. On August, 9, 1931, a colostomy was performed. Microscopic examination showed an adenocarcinoma. He died April 1, 1932.

A daughter, Emma R., age 47, the sole surviving member of the family, was admitted to the Presbyterian Hospital, New York, on December 10, 1935. She had had a mucous colitis for many years. Three months before admission her bowel movements, which had previously been two or three a day, changed to six or eight a day. Only once had she noticed a little blood in the stool. Examination showed a mass 10×5 cm. about the umbilicus. There was also a large fungating mass 4 cm. inside the anal sphincter, involving the anterior and left side of the rectal wall, with partial obstruction. A colostomy was performed. Microscopic examination showed carcinoma of the rectum, with metastases to the liver and mesentery. She died on December 28, 1935.

Environment has been considered a factor in the production of cancer. Various members of this family lived at seven different known addresses.

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BRIEF COMMUNICATION AND CASE REPORT

TOTAL GASTRECTOMY *

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NEW YORK

Case Report.—H. D., white, male; 35 years old; pharmacist. Admitted to St. Peter's Hospital, Brooklyn, New York, August 7, 1935. He complained of pain in the epigastrium and upper left abdominal quadrant, which occurred in paroxysms radiating upward and to the left. He had suffered this pain for about a year with intervals of abatement rather than remission. He had a sense of fulness whenever he ate solid or semisolid food. Vomited two to three times a day. Had noticed that his stools were streaked with blood and had lost 35 pounds in the last three months. He gave a history of treated lues four years previously but no other serious illness.

Examination of his abdomen revealed a palpable mass in the left upper quadrant, smooth and movable.

Roentgenologic Examination.—Inconclusive. An extensive polypoid new growth involving the upper and middle portion of the stomach was visualized but was not interpreted as malignant; rather, a luetic origin of the lesion was suggested. He was put on active antiluetic therapy and sent home. October 24, 1935, he was readmitted in somewhat worse condition than when he was discharged on August 24, 1935. Pain and vomiting had become aggravated and more tarry stools were evident. Roentgenologic studies showed some advance in the infiltrative lesion of the stomach and after a period of preparatory gastric lavage he was operated upon December 11, 1935.

Under open ether anesthesia an incision was made from the ensiform to the navel along the median side of the left rectus. The cartilages of the tenth and ninth ribs were cut without wounding the pleura and the stomach exposed. An infiltrating growth had invaded the fundus, the posterior wall and the cardiac portion of the lesser curvature. It was thought, however, that a narrow zone distal to the cardia was uninvolved and that an anastomosis between this section of the cardiac end of the stomach and the jejunum could be accomplished. A few enlarged lymph nodes were felt in the gastrocolic omentum. The liver was apparently free of malignant invasion. No adhesions were found other than a doubtful thickening between the fundus of the stomach and the spleen. The pylorus was clamped, divided, and the distal end sutured and inverted with a double purse string suture of chromic gut. The vessels of the greater curvature were clamped and the stomach freed from the colon. In freeing the adhesion to the hilus of the spleen, branches of the vein were wounded and it was found desirable to remove the spleen. In exploring the lesser curvature it was found that the infiltration of the neoplasm approached so close to the cardia that no gastric anastomosis could be accomplished. The esophagus therefore was clamped and divided close to the gastric wall and the stomach removed. A stout silk ligature was applied about the esophagus

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in the bite of the clamp. The transverse mesocolon was opened and a loop of jejunum immediately distal to its beginning was drawn up and secured to the diaphragm posterior to the esophageal hiatus, for a distance of three inches, by a running suture of silk. Stay sutures of silk were introduced lateral to this continuous suture. The jejunum was then opened with a cautery and the ligated end of the esophagus placed into it and secured by three interrupted silk sutures well proximal to the site of its occlusive ligature. The line of continuous sutures which effected the apposition of the jejunum and the diaphragm was now continued around and in front of the esophagus, and a few supporting interrupted sutures were placed in front of this. The ligated esophagus was thus introduced into a loop of jejunum which had been firmly secured to the diaphragm around the site at which the penetration had been effected. The esophagus lay without tension, ligated within the jejunal lumen. The mesenteric opening was secured to the displaced loop of jejunum. No jejunojejunal anastomosis was made. A jejunostomy, employing a No. 16F rubber catheter, was made after Witzel's method, a fold of omentum sealing the approximation to the abdominal wall, the catheter was drawn through a stab wound at the outer edge of the left rectus, two inches above the line of the umbilicus, and the median wound closed in layers without drainage.

A transfusion of 500 cc. of blood was given four hours after the operation. The patient was kept under morphine for three days. He was fed immediately through the jejunostomy tube with peptonized milk and salt solution. He received 2,000 cc. of milk and 1,000 cc. of normal salt solution on his third day and so fed in this manner until the seventeenth day. He was allowed to chew gum. On the fifteenth postoperative day he noted a regurgitation of fluid into his throat but was able to swallow it again. It seemed probable that the ligated esophagus had opened, as it was hoped would eventuate, and on the seventeenth day feeding by mouth was begun. This has been continued with increasing courage since that time. He is now eating cereals, soups, eggs and soft vegetables with chopped meat.

The pathologic examination showed an ulcerating infiltrative lesion of the stomach—an adenocarcinoma—involving all the muscular layers with many areas of myxomatous degeneration. Lymph nodes showed malignant invasion.

This case is reported because of the following points of interest:

(1) A method of esophagojejunal anastomosis is submitted which depends upon suture of the intestine to the diaphragm, the ligated esophagus being introduced into the intestinal lumen within that suture ring.

(2) A secondary jejunostomy, for nutrition, maintained the patient's weight and well being for 17 days, until the ligature of the esophagus had cut through; after continuity had been established, feeding by mouth was begun and maintained.

(3) The presence of ravenous hunger in the complete absence of the stomach is noted—without comment on present physiologic dicta.

(4) The absence of blood changes, up to this time, is noted.

(5) The fact that the spleen was removed is also noted, and the possibility that damage to the circulation of that organ may have played a part in some fatalities following total gastrectomy should not be ignored.

DISCUSSION.—DR. RICHARD LEWISOHN (New York) congratulated Doc-

tor Jennings especially on the fact that, to his knowledge, this was the first case surviving a total gastrectomy to be presented before the New York Surgical Society. Doctor Lewisohn wondered in how many instances Doctor Jennings's original procedure would be applicable, and said that one might well speculate on what would happen should the ligature fail to cut through properly. The procedure would seem to be applicable only in cases with a fairly long intra-abdominal esophagus. Doctor Lewisohn described a case in whom he had performed total gastrectomy in December, 1935, and stated that the patient died, due to a leak, within four weeks. The prognosis in total gastrectomy, especially for cancer, is not good. If the patient survives the operation, he succumbs, usually within a short period, of recurrence. He wished to inquire whether the microscopic sections of the cardiac end of the stomach showed esophageal mucosa.

DR. CARL EGGERS (New York) said that as he understood it, Doctor Jennings's operation of total gastrectomy had not been deliberately planned, but was in the nature of an experimental operation. That he had met the conditions found at operation in the brilliant way in which this was done was one of the most noteworthy features of his presentation. Total gastrectomy is a formidable operation, it is rarely attempted, and, when successfully performed, frequently fails as the result of some complication. Leakage with a fatal peritonitis is the usual cause of death.

There are two methods of anastomosis most frequently employed; an esophagoduodenostomy, or an esophagojejunostomy. The former is always subjected to great tension or there may be interference with the blood supply, both of which favor an insecure anastomosis. Doctor Jennings employed the latter method and emphasized two principles in its performance. He fastened the jejunum securely to the under surface of the diaphragm, thereby avoiding tension, and he kept the esophagus stump tied with a silk ligature until it cut through spontaneously, thereby preventing the entrance of organisms from the mouth and keeping the anastomosis at rest until it was healed. A jejunostomy below the anastomosis was used for feeding.

There are several points of interest connected with this case, the most important of which seems to be the feasibility of implanting an esophagus stump, devoid of a serous covering, into an organ which has a peritoneal coat. This problem has interested all surgeons who perform resections of the cardia or of the lower esophagus for carcinoma. Doctor Fischer of this society has described a method of implanting the esophagus stump into the fundus of the stomach after resection of the cardia, which involves the same principles emphasized by Doctor Jennings. He has also advocated leaving the stump closed and permitting the ligature to cut through at a later date. The principle seems sound, as it will effectually put the anastomosis at rest, and at the same time prevents mouth organisms from coming down. That healing of an uncovered esophagus stump into an organ covered with peritoneum can take place is proved by the case presented tonight. Personally, I have a beautiful specimen illustrating this point. After resecting a carcinoma of the cardia from above, I had implanted the *open* esophagus stump into the fundus of the stomach. The patient died ten days later as the result of a small mediastinal abscess. The suture line was intact, the coats firmly united. Soiling of the field had apparently occurred at the time of operation and might have

been avoided by implanting the *closed* stump into the stomach. In case one fears that a silk ligature may not cut through one may use chromic catgut, which would dissolve in a reasonable time.

CORRECTION

In the title of the article "Sacrococcygeal Transrectal Approach for High Rectovaginal and Vesicovaginal Fistulae" by Dr. John C. A. Gerster which appeared in the ANNALS OF SURGERY, Vol. 104, No. 2, pp. 244-247, August, 1936, the word Vesicovaginal should be corrected to Rectovesical.

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STAGE OPERATIONS IN SEVERE HYPERTHYROIDISM

FRANK H. LAHEY, M.D.

BOSTON, MASS.

As THE result of our experience with 14,600 goiter operations, we have developed quite definite convictions concerning the fatalities which, though few, are inevitably associated with subtotal thyroidectomy in patients with severe degrees of hyperthyroidism.

While we cannot present indisputable evidence as to what are the effects of operative procedures upon the organism that brings about these deaths, we have repeatedly demonstrated that when we perform the operation of subtotal thyroidectomy in stages, the mortality rate is lowered, and that when we lessen the number of stage operations, the mortality rate rises. With this basic principle in mind, we have published and preached a formula relating to operations upon patients with serious hyperthyroidism which we believe is sound, and which will impel one to be conservative, and a plan which if consistently pursued will result in a lower mortality rate.

Our formula for low mortality rates has always been to assume that if a patient died after subtotal thyroidectomy, he would probably not have died had we performed a two stage subtotal thyroidectomy, after a right first stage subtotal hemithyroidectomy, sending the patient home for six weeks and then having him return for a second stage left subtotal hemithyroidectomy. Should a patient die after a right first stage hemithyroidectomy, we contend that patient would probably not have died after a preliminary pole ligation, and should a patient die after preliminary bilateral pole ligations, the patient would probably not have died had but one superior pole been ligated and the other pole ligated a week later.

The advent of preoperative preparation of patients with hyperthyroidism by the preliminary administration of iodine, usually in the form of Lugol's solution, has been a great advance in the management of these dangerous states. With it, however, have come certain unsound practices which, in some measure at least, have lessened the value of this great advance. One is the promiscuous employment of iodine without regard for the fact that iodine is of value in hyperthyroidism only in the preparation for operation, thus saturating them with iodine prematurely. Another is the tendency to assume that with the advent of the preoperative employment of Lugol's solution, pre-

* Submitted for publication July 2, 1936.

liminary pole ligations are no longer necessary. There can be no dispute but that the employment of iodine in the preparation of patients with hyperthyroidism for operation has lessened the number of stage operations, but in spite of this and all other advances in the methods of preparing these patients, there remains, as stated above, an apparently inevitable mortality. As long as this mortality exists there will be a need for graded operative procedures, and while we have never succeeded in eliminating mortality completely for any given year, we feel sure that our low mortality rates in primary hyperthyroidism are definitely related to the employment of graded procedures in patients seriously ill.

TABLE I

OPERATIVE MORTALITY AFTER MULTIPLE PROCEDURES UPON CASES OF PRIMARY AND SECONDARY HYPERTHYROIDISM

Ten Year Period, 1926-1935, Inclusive
5,626 Operations

	Per Cent of Patients with Multiple Operations	Operative Mortality
Primary hyperthyroidism.....	28.9	.48
Secondary hyperthyroidism.....	17.8	1.55

While the mortality of secondary hyperthyroidism has always been higher than that of primary, one cannot help but deduce from these figures that we have not performed enough multiple stage procedures in this type of hyperthyroidism.

In a recent article¹ dealing with our experience with pole ligation, we stated that it was an almost impossible undertaking to set down in words a description of the features of a case of hyperthyroidism which may be done in one stage, in two stages or one that should be preceded by preliminary pole ligation. Since the decision as to the type of operative procedure to apply to

TABLE II

THE POSTOPERATIVE EFFECT ON WEIGHT IN FIFTY PATIENTS
WITH PRELIMINARY POLE LIGATION

Weight gain in 32 patients.....	64%
Weight loss in 14 patients.....	28%
No change of weight in 4 patients.....	8%

a given case is so difficult to make, it is obviously impossible to standardize the problem by dividing the patients into these groups.

TABLE III

THE EFFECT ON PULSE IN FIFTY PATIENTS WITH
PRELIMINARY POLE LIGATION

Decrease in 31 patients.....	62%
Increase in 17 patients.....	34%
No change in 2 patients.....	4%

We offer that evidence that the employment of incomplete procedures produce at least temporary improvement in these cases and will discuss the

HYPERTHYROIDISM

features which in our experience has convinced us they are serious risks. The problem of multiple stage procedures then concerns itself almost entirely with estimations of the severity of intoxication.

TABLE IV

THE EFFECT ON BASAL METABOLISM IN FIFTY PATIENTS
WITH PRELIMINARY POLE LIGATION

Decrease in 33 patients.....	66%
Increase in 14 patients.....	28%
No change in 3 patients.....	6%

TABLE V

GAIN IN WEIGHT BETWEEN FIRST AND SECOND STAGES HEMITHYROIDECTOMY
TWO HUNDRED FIFTY CASES

	Primary Hyperthyroidism 149 Cases	Secondary Hyperthyroidism 101 Cases	Total Two Stages
Gain in weight.....	86.5%	74%	82 %
Loss of weight*.....			14.8%
No change.....			3.2%

* All show drop in pulse rate and drop in metabolism.

TABLE VI

PULSE RATE CHANGE BETWEEN FIRST AND SECOND STAGES HEMITHYROIDECTOMY
TWO HUNDRED FIFTY CASES

	Primary Hyperthyroidism 149 Cases	Secondary Hyperthyroidism 101 Cases	Total Two Stages
Pulse rate drop.....	80%	64%	73.2%
Pulse rate unchanged.....			24.4%
Pulse rate increased.....			2.4%

TABLE VII

BASAL METABOLISM CHANGE BETWEEN FIRST AND SECOND STAGES HEMITHYROIDECTOMY
TWO HUNDRED FIFTY CASES

	Primary Hyperthyroidism 149 Cases	Secondary Hyperthyroidism 101 Cases	Total Two Stages
Drop in metabolism.....	90%	76%	84.8%
Unchanged.....			13.2%
Increased.....			2 %

It will always be true that of the small number of patients with hyperthyroidism dying in our Clinic each year postoperatively, some will be the result of cardiac complications, some will be the result of pulmonary com-

FRANK H. LAHEY

TABLE VIII

HIPPURIC ACID LIVER FUNCTION TEST IN HYPERTHYROIDISM*

HIPPURIC ACID LIVER										Operative Procedure		
Case	Age	Sex	Dur. of Disease	Wt. Loss	Basal Rate			Hippuric Acid Determination†		Clinical Diagnosis	Operative Procedure	
					On Adm.	On 6th Day	On Adm.	Preop.	6 Days			
									P. O.			
1	31	F	18 mos.	None	+81	+55	1.41	2.93	2.12	Primary Hyperthyroidism	Hemithyroidectomy	
										P. H.	Hemithyroidectomy	
										P. H.	Hemithyroidectomy	
										P. H.	Hemithyroidectomy	
										P. H.	Subtotal Thyroidectomy	
										P. H.	Subtotal Thyroidectomy	
										Ad. Goiter with Hyperthyroidism	Subtotal Thyroidectomy	
										P. H.	Subtotal Thyroidectomy	
										P. H.	Subtotal Thyroidectomy	
										P. H.	Subtotal Thyroidectomy	
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										P. H.	Subtotal Thyroidectomy	

* Unpublished Work of E. C. Bartels (Medical Dept. Lahey Clinic).

† Normal Hippuric Acid Secretion, Three Grams.

Constructed by Doctor Bartels, shows the possible depression of liver function as suggested by hippuric acid determinations, its elevation after several days of preoperative hospital preparation and its tendency to fall, perhaps due to the postoperative thyroid reaction, when determined six days after operation.

Further investigations are being carried on relative to late postoperative hippuric acid determinations, taken when these patients have attained normal postoperative metabolic levels.

plications, a trivial percentage will be the result of operative complications and the remainder will be the result of serious thyroid reactions. The first three states are perhaps in some measure influenced by multiple stage procedures, but the last state, postoperative thyroid reactions, is undoubtedly more definitely influenced by multiple stage procedures than any or all of the other three, and because of this, it becomes extremely important to consider the factors, when present, which indicate a severe grade of hyperthyroidism. These factors are divisible into those to be appreciated before the operation and those to be interpreted as indications of danger during operation.

If it be accepted that with hyperthyroidism there is quite constantly associated an increase in basal metabolism, and there are but very few today who fail to accept this assumption, then it must be accepted that hyperthyroidism is largely a disease of excessive combustion. Recent researches in liver function tests with hippuric acid undertaken in our Medical Department by Dr. E. C. Bartels corroborate what we and many others have long suspected, that hyperthyroidism lowers liver function and improvement from hyperthyroidism reelevates liver function.

TABLE IX
SPECIFICITY OF HIPPURIC ACID TESTS FOR LIVER FUNCTION IN PATIENTS SUSPECTED OF
HYPERTHYROIDISM

Case	Age	Sex	Clinical Impression*	B.M.R.	Hippuric Acid
1	40	F	Primary Hyperthyroidism in Partial Remission	-12 -10	3.08
2	32	F	Primary Hyperthyroidism Gland Not Typical	± 0 - 7	3.00
3	44	F	Adenomatous Goiter with Question- able Thyroidism	+10	3.14
4	42	F	Adenomatous Goiter with Hyperthy- roidism	+10 + 6	3.66
5	33	F	Mildly Toxic Adenomatous Goiter	+ 5	3.26
6	43	F	{ Adenomatous Goiter with Question- able Recurrent Hyperthyroidism }	+14	3.33
7	47	M		+15 +12	3.23

* Prior to hospital study.

It is of interest to note that in these seven patients, all of whom were suspected of hyperthyroidism but upon hospital study proved not to have it, the hippuric acid determinations were normal.

That thyroid intoxication is the result of excessive thyroid secretion may be assumed, purely by deduction, since adequate subtotal thyroidectomy results in complete and permanent relief from this intoxication. The degree of damage from this intoxication may be estimated by both direct and indirect evidences. Of the direct evidences, the most definite and dependable, in adults particularly, is tachycardia. The next and but slightly less dependable is weight loss, and the least dependable evidence of severity of intoxication is basal metabolism. The indirect evidences, not of the intensity

of the intoxication entirely, but rather of the danger of operative fatality, are associated with the age of the patient, and so his or her ability to withstand the effects of excessive energy production and the length of time over which the effects of excessive energy production have been affecting the organism. During the period of preoperative preparation, valuable indirect evidence becomes available also as to what degree the actual excessive production of energy is resistant to its influence by iodine medication and to what degree its effects are counterbalanced by rest and a diet aimed toward overcoming weight loss and possibly restoring liver glycogen.

Tachycardia, although occasionally inconsistent, is, I believe, the best single evidence of the degree of hyperthyroidism. Patients who run persistently high pulse rates fall definitely into the bad risk group. I have a great many times, in writing on this subject, urged that when patients with hyperthyroidism are seen for the first time, a notation be made on the record as to the examiner's opinion of the severity of the disease, the probable need of a multiple stage procedure and the probable type of operation that will be needed. If this is done the tachycardia at the time of the first examination will be at its highest. Likewise, the patient's activation will be at its worst and if a prophecy as to the probable need of multiple stage procedures be recorded at this time, it will consistently be on the side of safety. If on the other hand, such a patient be seen in the Clinic and no note made as to the severity of the disease and need for stage procedures and a decision as to these stage procedures reached the day before operation, after the patient has had a week's rest in bed, and a large fluid, glucose and iodine intake, then one may forget that but a week previously that patient was thought to be a very bad risk patient. After this week's period of preparation the tachycardia may have markedly lessened, the basal rate dropped and the weight risen. Such deceptive observations tend to lead one into performing a one stage thyroidectomy that may result in a fatality. The decision at the operating table for or against a two stage hemithyroidectomy or a preliminary pole ligation will occasionally be easy, but in many more cases it will be an extremely difficult one and not infrequently based upon features that are far from convincing in either direction. In such a situation of uncertainty a record of one's impression of the severity of the disease and need for stage procedures made at the patient's worst when first seen will be of great value in helping to make this difficult and dangerous decision.

One can, I believe, more safely generalize about high trends of tachycardia than about low pulse rates. Severe and dangerous hyperthyroidism can exist in the presence of such relatively low pulse rates as 110, 120 or 130, but persistent pulse rates of 150 and upward are certain evidence of severe hyperthyroidism and a warning that should make one correlate this danger indicating factor with other danger signals to be spoken of later, and seriously consider and determine as to whether or not a multiple stage procedure should be done.

Weight loss of considerable amount, 30, 40, 50 or more pounds, provided, of course, that the patient has not been on a restricted diet, is definite evidence that the excessive production of energy has resulted in the patient burning a fraction of himself and suggests strongly the need for multiple stage measures. If one wishes to keep the mortality of subtotal thyroidectomy for hyperthyroidism low, it will not suffice to employ multiple stage procedures in patients only who are so ill with hyperthyroidism that stage operations must obviously be done. There is a large group of borderline cases in whom unexpected postoperative reactions will occur and occasionally result in fatalities. In many patients, multiple stage operations must be performed on the suspicion that a serious postoperative thyroid reaction might occur. It is, therefore, wise to accept a large weight loss as evidence of the severity of the intoxication even though other evidences may be lacking. Likewise, as indirect evidence, one must accept the probability that those patients who have had hyperthyroidism for a long time have perhaps suffered considerable liver damage and at any rate are often more capable of having a severe postoperative reaction than the patient who has had hyperthyroidism but a short time.

There seems little question but that age plays a great part in the mortality associated with any trying operative ordeal which an individual has to withstand. For example, the mortality rate in our patients below 50 years having subtotal gastrectomy is practically half that of patients over 50 years having this operation. Similar influences are effective in elderly patients with severe degrees of hyperthyroidism. We have always been impressed with the fact that young individuals, even when in quite severe states of hyperthyroidism, could and would withstand complete subtotal thyroidectomies much better than older individuals in much less severe states of thyroid intoxication.

Should the question of possible multiple stage procedures arise and still not be capable of settlement on the information already discussed, then one should make use of the indirect evidence available in order to arrive at such a decision. If during the period of hospital preparation there has been a slight weight loss or no weight gain in spite of a high caloric diet, if the basal metabolism and pulse rate have risen or have even not diminished, in such a case under discussion as to possible multiple stage procedure, the decision should be in favor of them.

Multiple stage procedures should, I feel, always be considered in all patients who have recently had vomiting or diarrhea or any of the signs of a thyroid crisis. This procedure will also at times be necessary in thyrocardiacs with advanced degrees of decompensation and associated high degrees of hyperthyroidism.

Not infrequently, in spite of the above stated facts, one will still be uncertain as to whether or not patients will safely endure a complete subtotal thyroidectomy or will need a two stage right and left subtotal thyroidectomy.

Then the decision as to whether or not but one-half of the operation should be performed must be left until one-half of the operation is completed. The operation is interrupted at this point, the history and findings reread and certain things in the course of the operation up to this point reviewed and their significance evaluated as an aid in settling as to whether or not to go on with a left subtotal hemithyroidectomy. When one is in doubt in reviewing such a situation, some of the facts which should influence one in favor of multiple stage measures are here submitted: A progressively rising

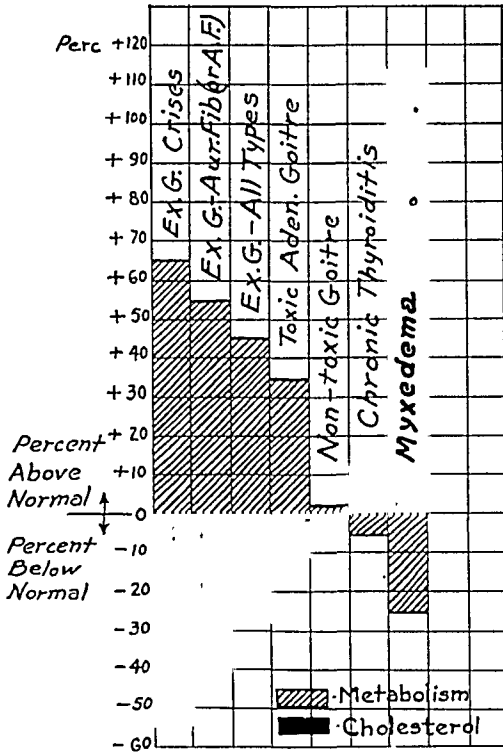


CHART 1.—The correlation of hypocholesterolemia with the grades of hyperthyroidism and that of hypercholesterolemia with the grades of hypothyroidism is shown by Dr. L. M. Hurxthal in previous reports from this Clinic.

against multiple stage measures is a daily one and one that often has to be settled several times each day. While one does not routinely have either blood iodine or blood cholesterol reports on every case, it is possible in cases under consideration for multiple stage operations to have either or both of these reports and they provide additional data to be utilized in making these difficult decisions.

Dr. L. M. Hurxthal has published the results of his investigations in this Clinic on blood cholesterol in thyroid states in several articles on this subject. It has been convincingly demonstrated by him that there is a high blood cholesterol with hypothyroidism and a low blood cholesterol with hyperthyroidism. It has further been demonstrated by him that the degree of hypocholesterolemia relates itself to the degree of hyperthyroidism, and likewise, that the degree of hypercholesterolemia relates itself to the degree of hypothyroidism.

ing pulse rate, an increasingly widening pulse pressure (perhaps the best blood pressure indication of dangerous toxicity), a high demand for anesthesia depth and a demand for unusually high percentage of oxygen, the fact that any technical difficulties have been encountered such as an excessive amount of bleeding, the employment of an unusual amount of time to complete the hemithyroidectomy or any technical complication which has rendered the operation unduly difficult. In this respect, it must be remembered that if difficulties have been encountered, in right subtotal hemithyroidectomy they may quite likely be encountered on the other side and so the doubtful risk patient committed to a predictable hazard which is more than usual.

Because we constantly have so many patients in severe degrees of thyroid intoxication, the problem of deciding for or

In a recent further investigation on this subject, Doctor Hurxthal has concluded that high blood cholesterol is the result of the inability of the hypothyroid patient to metabolize cholesterol and that the low blood cholesterol in the hyperthyroid patient is due to excessive destruction or utilization of cholesterol. Very low blood cholesterol, therefore, must be accepted at least as presumptive evidence of a severe grade of hyperthyroidism. Unfortunately, the range of abnormal blood cholesterol in the downward direction is so great, 120 being low normal and 70 the lowest hypocholesterolemia we have seen with hyperthyroidism, that as an indicator of a possible serious postoperative reaction it is not as valuable a factor as we would like it to be.

During the last two years, Mr. H. J. Perkin has been carrying on investigations in the Clinic on the relation of blood iodine to hyperthyroidism, and has demonstrated that in a majority of patients having hyperthyroidism, there is an elevation of the blood iodine. Preoperatively out of a group of 331 patients with hyperthyroidism, 224 or about 70 per cent had an elevation of blood iodine. Following relief from hyperthyroidism by subtotal thyroidectomy, the elevation in blood iodine in this group promptly dropped to normal in direct proportion to the drop in basal metabolism. Of these 331 cases of hyperthyroidism, however, 107 or about 30 per cent had a normal preoperative blood iodine which rose to above normal after operation, and later with the drop in the metabolism to normal again returned to normal. This is an interesting and somewhat confusing phenomenon from the point of view as to whether or not blood iodine represents the iodine fraction of circulating thyroxine. Of direct interest to us, however, in our search for every indication of severity of intoxication in patients with hyperthyroidism is the fact that in the 70 per cent of patients having blood iodines which were elevated preoperatively (224) multiple stage operations were performed on 38 patients (17.9 per cent), while of the 107 (30 per cent) patients with hyperthyroidism having normal blood iodines preoperatively, multiple stage procedures were performed in 49 cases (45.8 per cent). When one realizes that the grading of risks and selections of a multiple stage procedure in those cases were made without reference to, or knowledge of, what the blood iodine values were and when one appreciates that the average percentage of multiple stage procedures in our entire group of patients with hyperthyroidism is almost 22 per cent, then one must seriously consider the possibility that low blood iodines are an indication of a severe grade of hyperthyroidism and one in which multiple stage procedures must be considered and will probably need to be employed in a higher percentage of cases than in those patients with high blood iodines. If one realizes also that in this group of patients with low preoperative blood iodines, there is a higher percentage of recurrent hyperthyroidism than in the average group, this becomes additional evidence that low preoperative blood iodines in patients with definite hyperthyroidism are probably an indication of severity of the disease.

TABLE X

STAGE OPERATIONS IN RELATION TO THE PREOPERATIVE BLOOD IODINE LEVEL		
	Elevated Blood Iodine	Normal Blood Iodine
No. of Cases.....	224 (70%)	107 (30%)
Stage Oper.....	38	49
% of group.....	17.9	45.8

Note that in the 70 per cent of patients having high preoperative blood iodine but 17.9 per cent had multiple stage operations, but that in the 20 per cent having low preoperative blood iodine 45.8 per cent had multiple stage procedures.

SUMMARY

Since the necessity for and the percentage of multiple stage operations should, we believe, be directly related to the severity of the hyperthyroidism, we have discussed the direct and indirect evidences of hyperthyroidism with the possible relation of atypically low preoperative blood iodines as indications of a severe degree of thyroid intoxication.

REFERENCE

- ¹ Lahey, Frank H., and Schwalm, L. J.: Pole Ligation in the Treatment of Hyperthyroidism. Surg., Gynec., and Obstet., 63, 69-76, July, 1936.

HYPERPARATHYROIDISM IN SIBLINGS

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VON RECKLINGHAUSEN first recognized generalized osteitis fibrosa cystica as an entity in 1891, but its etiology was not determined until much later. So many comprehensive reviews of the clinical, metabolic, pathologic and surgical aspects of hyperparathyroidism have appeared in the literature that it is not within the scope of this report to elaborate in detail upon these points. The main features of this disturbance, however, will be illustrated in the case reports of two members of the same family. The bony lesions of these two patients, brother and sister, were first diagnosed erroneously—roentgenologically in one case and pathologically in the other—as giant cell tumors. Later both patients were successfully treated for hyperparathyroidism associated with generalized osteitis fibrosa cystica, by the surgical removal of parathyroid adenomata. Though this disease is not considered to be of a familial nature, these cases illustrate that it may occur in more than one member of the same family and must be differentiated, therefore, from fragilitas ossium and similar familial skeletal disturbances.

CASE REPORTS

Case 1.—An Italian girl, age 17, entered the University of California Hospital January 18, 1934. One year previously she had injured her left shoulder and sustained a pathologic fracture of the neck of the left humerus. She had had no complaints prior to that time. A roentgenologic diagnosis of giant cell tumor was made, the region was immobilized and a course of roentgen therapy instituted. She felt improved for a short time, but later noticed the insidious development of polydipsia, polyuria, constipation, increased fatigability, severe attacks of left ureteral colic, and pain in the left humerus and right tibia. At this time she was seen by Dr. Harold Brunn, who referred her to the University of California Hospital.

Physical examination revealed a girl of short stature, with a waddling gait. She was well developed and her skeletal musculature showed no clinical signs of hypotonicity, although prolonged exertion caused fatigue. Her teeth were in good condition. There was a visible, palpable tumor, apparently located in the left lobe of the thyroid gland. Limitation of motion and swelling of the left shoulder joint were present, as well as tenderness over the left humerus, right tibia, and left kidney.

TABLE I

DAILY AVERAGE EXCRETION OF CALCIUM AND PHOSPHORUS IN CASE I

Case I. 24-hour Average						
	Stool	Urine	Total	Intake	Balance	Blood
Calcium.....	0.1440	0.3727	0.5167	0.929	-0.4238	19.20 mg. per cent
Phosphorus.....	0.1703	0.7027	0.8730	0.7766	-0.0964	2.56 mg. per cent
Phosphatase.....					•	33.2 units

Submitted for publication January 17, 1936.

The serum calcium level was elevated to 19.2 mg., and the plasma phosphatase to 33.2 (Kay-Jenner) units per 100 cc. of blood; the serum phosphorus was lowered to 2.5 mg. A study of the balance of the intake and output of calcium, by Aub's method,¹ revealed a markedly negative calcium balance. On a daily intake of 0.929 Gm. of calcium, the loss was 0.5167 Gm., or a negative balance of 0.4238 Gm. in 24 hours, 75 per cent of which was excreted in the urine (Table I). The urine was cloudy, yellow, acid



FIG. 1.—Roentgenogram showing marked thinning of the cortex and demineralization of the humerus; there is a cyst of the humeral head.

FIG. 2.—Roentgenograms of the right tibia showing a large cyst. (A) Before operation. (B) Thirteen months after the removal of the parathyroid adenoma.

in reaction, and had a specific gravity of 1.022. The test for sugar was negative and there was the faintest possible trace of albumin. From 20 to 25 red blood cells per high dry field were found in the uncentrifuged specimen. The intramuscular phenolsulphonephthalein test showed an excretion of 55 per cent of the dye after two hours. Examination of the blood showed a hemoglobin of 80 per cent, red blood cells 4,230,000, white blood cells 7,870, with 75 per cent polymorphonuclear neutrophils, 1 per cent eosinophils, 8 per cent large lymphocytes, 13 per cent small lymphocytes, and 3 per cent monocytes.

The bleeding time was 1.5 minutes (Duke) and the clotting time was five minutes (Lee and White). The tests of blood chemistry showed a fasting blood sugar level of 103.4 mg., non-protein nitrogen 52.1 mg., cholesterol 217.9 mg., serum albumin 4.69 Gm., serum globulin 2.19 Gm., and total protein 6.83 Gm. per 100 cc. of blood. The blood Wassermann and Kahn tests were negative. The basal metabolic rate was plus 1. Serial electrocardiograms showed a shortened Q-T interval (electric systole), delayed auriculo-ventricular conduction and slurred ventricular complexes, indicating hypotonicity of the cardiac musculature.²



FIG. 3.—(A) Parathyroid adenoma within the capsule of the left lobe of the thyroid gland. (B) Cut section of the adenoma, showing cystic degeneration. (C) Gross appearance of the adenoma after enucleation (Case 1).

Roentgenograms revealed generalized demineralization of the entire skeleton, characterized by a uniform granular osteoporosis. Cysts of varying sizes, some with cortical expansion, were present in the humeri (Fig. 1), right tibia (Fig. 2), metacarpal and pubic bones. The trabeculae of the long bones were indistinct and the cortex was thinned. Granular mottling was noted in the skull. The renal shadows were denser than normal and several small calculi were present in the left kidney. Gastro-intestinal roentgenologic series revealed a 40 per cent retention of barium in the stomach after six hours, suggesting hypotonicity of the gastro-intestinal musculature.

After exploring the retrotracheal and retro-esophageal planes of the neck, as well as

palpating the anterior and posterior mediastinum, a parathyroid adenoma, weighing 11.8 Gm. and measuring 3.7 by 2.8 by 3 cm., was removed from within the capsule of the left lobe of the thyroid gland at its inferior pole (Fig. 3). The right lobe appeared to be normal. A normal right inferior parathyroid gland was seen attached to the posterior capsule. The adenoma was inclosed in a smooth capsule, and the cut section revealed a characteristic yellowish-brown surface with a cystic center. The tissue was soft and glistening. The capsule was partially surrounded by a thin rim of normal parathyroid tissue. Microscopic sections showed the tissue to be composed of diffuse sheets or columns of epithelial cells, the majority of which were large, with eccentrically placed hyperchromatic nuclei and abundant clear cytoplasm, conforming to the *wasserhelle* or water-clear type of cell as described by Mallory and Castleman.⁹ Some areas showed a pattern with a basal arrangement of the nuclei suggesting a pseudoglandular formation. There were also many groups of typical chief cells of smaller size, and transitional *wasser-*

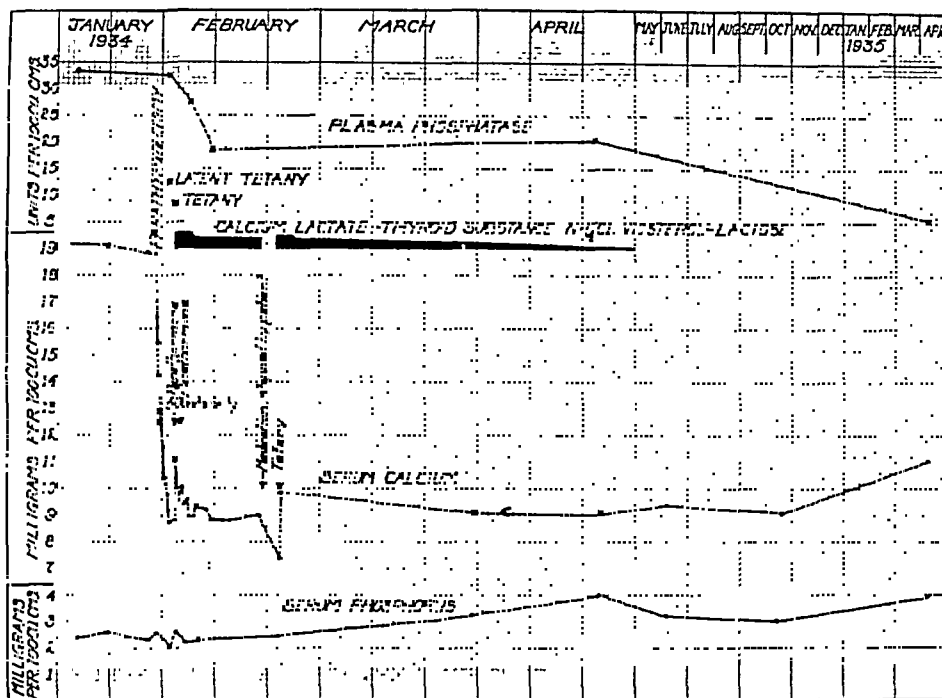


CHART I.—Showing the changes in the levels of serum calcium and phosphorus, and plasma phosphatase following the removal of the parathyroid adenoma (Case 1).

helle cells. Rarely a small group of light oxyphil cells could be seen. These cellular elements were supported by a stroma of fine fibrous tissue.

On the second day after operation, with a serum calcium level of 10.2 mg., the patient developed latent tetany and, on the morning of the third day, with a serum calcium level of 8.8 mg., she had spontaneous parathyroid tetany (Chart 1), characterized by carpopedal spasms, numbness, and paresthesias. Treatment with parathormone, calcium lactate, thyroid substance, ammonium chloride, lactose, and viosterol brought the calcium and phosphorus in the blood to a normal level. The pain and tenderness in the bones disappeared within three days after operation. The patient developed a positive calcium balance, with normal levels of calcium, phosphorus, and phosphatase in the blood; she no longer had pain and tenderness in the bones, hematuria or ureteral colic. Roentgenologically the skeleton showed increased calcification or complete obliteration of the cysts, 13 months after the removal of the parathyroid adenoma. The electrocardiogram revealed that the shortened Q-T interval had become prolonged and the other abnormal findings had reverted toward the normal. There was no retention of barium in the stomach after six hours. Both of these findings suggest a change from a state of muscu-

lar hypotonicity toward normal. At the last examination, she had no symptoms except some limitation of motion of the left shoulder joint resulting from the cystic formation and pathologic fracture.

Case 2.—After the first patient was studied, it was discovered that her brother, age 23, was being treated for a giant cell tumor of the mandible. At this time eight other members of the family were examined, but no clinical or metabolic evidence of skeletal or renal disease was found. Seven months before we saw this second patient, he had noted a painful swelling of the symphysis of the mandible and later sustained a pathologic fracture. A biopsy revealed a giant cell reaction which was interpreted as being indicative of a giant cell tumor. The patient was given a course of roentgen therapy, without improvement. He then developed general malaise and easy fatigability but had no pains in other parts of his skeleton and no urinary symptoms. Because of his sister's improvement, he came to the hospital for further investigation.

Physical examination revealed a well developed man of short stature, with a tender swelling of the mandible and a small palpable nodule in the left lobe of the thyroid gland. His teeth were sound. There was no clinical evidence of hypotonicity of his skeletal musculature or tenderness over his bones. The remainder of his examination was negative.

The serum calcium was elevated to 17.5 mg., the plasma phosphatase to 10.3 units (Kay-Jenner) per 100 cc. of blood, and the serum phosphorus was lowered to 1.5 mg. There was a markedly negative calcium balance. On a daily intake of 0.1040 Gm. of calcium, the loss was 0.3782 Gm., or a negative balance of 0.2742 Gm. in 24 hours, 80 per cent of the excretion being in the urine (Table II). Urinalysis revealed clear, yellow,

TABLE II

DAILY AVERAGE EXCRETION OF CALCIUM AND PHOSPHORUS IN CASE 2

	Case 2. 24-hour Average					
	Stool	Urine	Total	Intake	Balance	Blood
Calcium.....	0.0480	0.4302	0.4782	0.1040	-0.3742	18.20 mg. per cent
Phosphorus.....	0.2801	0.7676	1.0477	0.8480	-0.1997	2.10 mg. per cent
Phosphatase.....						10.3 units

neutral urine, without albumin or sugar. The centrifuged specimen showed a rare hyaline cast and 10 pus cells per high dry field. No red blood cells were found. Examination of the blood showed the hemoglobin to be 90 per cent, red blood cells 4,300,000 and white blood cells 4,150, with 60 per cent polymorphonuclear neutrophils, 26 per cent lymphocytes, 4 per cent eosinophils, and 14 per cent monocytes. The blood sugar estimation was .068 mg., and the non-protein nitrogen was 30.6 mg. per 100 cc. of blood. The blood Wassermann and Kahn tests showed a four plus reaction. The basal metabolic rate was minus 23. The kidneys excreted 35 per cent of the phenolsulphonephthalein after two hours. The Q-T interval of the electrocardiogram was shortened.

Roentgenograms revealed generalized changes characteristic of primary hyperparathyroidism. A generalized demineralization of the skeleton was noticeable, with findings similar to those in Case 1. This patient had only one cyst of the symphysis of the mandible (Fig. 4) and a small cyst in one of the phalanges. There were no renal calculi present. Roentgenograms of the esophagus showed a notched deviation to the right just below the level of the larynx (Fig. 5). Otherwise the gastro-intestinal series was negative.

An adenoma of the left inferior parathyroid gland, weighing 6.5 Gm. and measuring 3 by 2 by 2 cm., was removed from a retrotracheal position on the same plane as the esophagus (Fig. 6). The palpable nodule in the left lobe proved to be a small adenoma of the thyroid gland. The gross appearance of the parathyroid adenoma was charac-



FIG. 4.—Roentgenogram showing a cyst of the mandible with a pathologic fracture (Case 2).

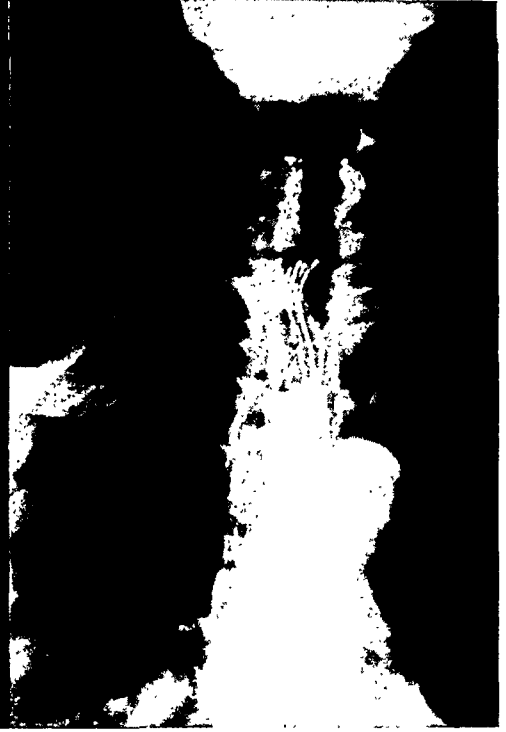


FIG. 5.—Roentgenogram showing the deflection of the esophagus by a retrotracheal parathyroid adenoma (Case 2).

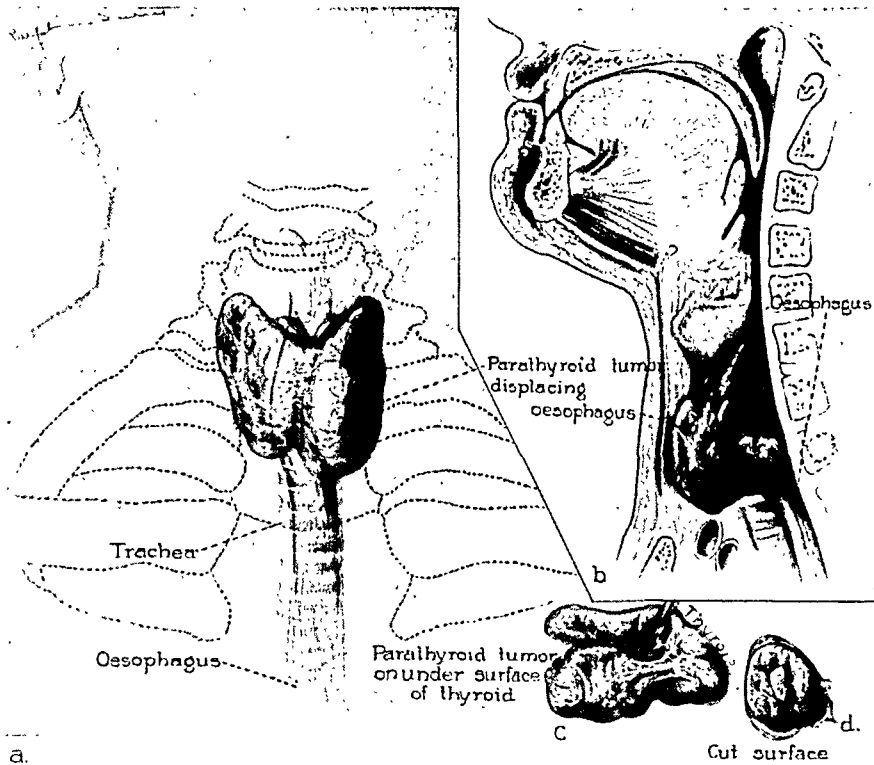


FIG. 6.—The position of the parathyroid adenoma in Case 2; (a) Anteroposterior view, showing the deflection of the esophagus to the right. (b) Left lateral view demonstrating the retrotracheal position of the adenoma. (c) Comparative sizes of the adenoma and the left lobe of the thyroid gland. (d) Cut surface of the adenoma.

HYPERPARATHYROIDISM

teristic and it had a thin rim of compressed normal parathyroid tissue on its border. Microscopically, it was composed mainly of chief cells with numerous large groups of pale oxyphil cells. No *wasserhelle* cells were seen.

No signs of tetany developed, and the blood chemistry returned to normal (Table III and Chart 2). Fourteen months after operation, the patient was entirely free from

TABLE III

DAILY AVERAGE EXCRETION OF CALCIUM AND PHOSPHORUS IN CASE 2

HIGH CALCIUM, LOW PHOSPHORUS DIET POSTOPERATIVE STUDIES

First period 4 days, 24-hour Average

	Stool	Urine	Total	Intake	Balance	Blood
Calcium*.....	0.5960	0.1922	0.7882	0.8570	+0.0688	16.99 to 9.34 mg. per cent
Phosphorus.....	0.1790	0.0643	0.2433	0.7160	+0.4727	1.93 to 2.74 mg. per cent

Second period 3 days, 24-hour Average

Calcium†.....	0.6933	0.0265	0.7198	1.5823	+0.8625	9.70 mg. per cent
Phosphorus.....	0.1433	0.3307	0.4740	1.2940	+0.8200	2.44 mg. per cent

* The first postoperative study was from March 19 to March 22, inclusive. There was no intake on March 19—the day of operation. No calcium was given other than in the diet. Aspirin and codeine were the only drugs administered.

† The second postoperative study was from March 23 to March 25, inclusive. No calcium was given other than that in the diet. Phenobarbital was the only drug administered.

symptoms, the cyst of the mandible was becoming calcified and smaller, and calcification of the demineralized skeleton was taking place. The shortened Q-T interval of the electrocardiogram became prolonged and his renal function improved. Fatigue, which

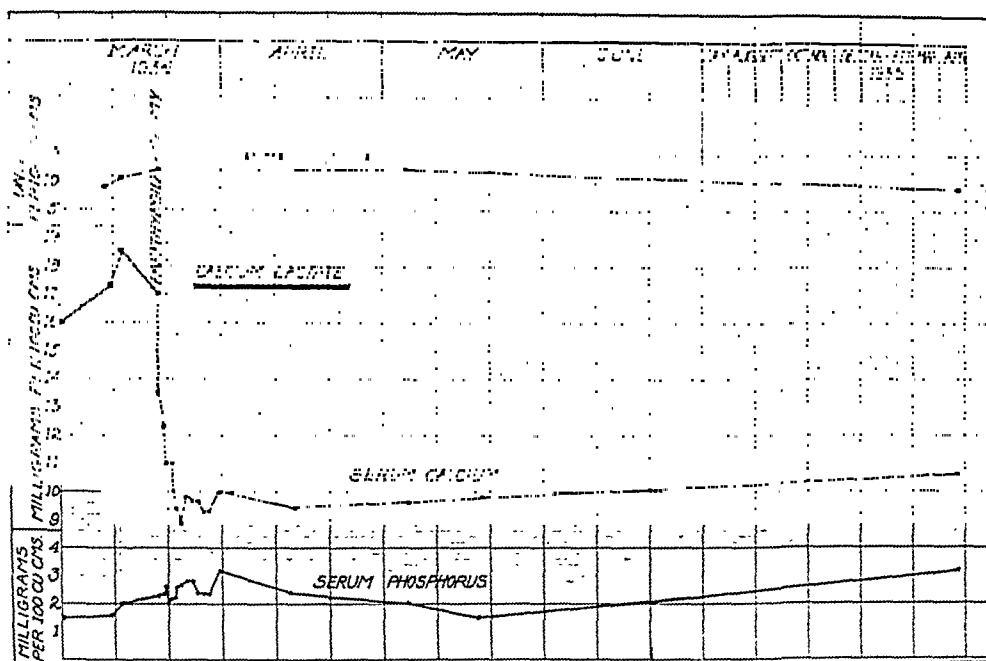


CHART 2.—Showing the changes in the levels of serum calcium and phosphorus, and plasma phosphatase following the removal of the parathyroid adenoma (Case 2).

had been an outstanding symptom, disappeared completely and the patient was able to perform manual labor.

COMMENT.—These two case reports illustrate the clinical, metabolic, and roentgenologic findings associated with the classic type of von Recklinghausen's disease. The levels of calcium and phosphorus in the blood were striking (Tables I and II). In both cases there was evident hypercalcemia. Conversely, the phosphorus was lower than normal. In the first case, the phosphatase was definitely elevated. In the second, it was not so obviously so, and we are inclined to correlate this with the lessened involvement of bone, inasmuch as the amount of phosphatase is an index of the activity of bony metabolism (destruction and repair).

One patient had renal calculi; the other did not. On the basis of the metabolism, one could not anticipate which patient would have kidney stones, since, in both instances, the excessive urinary loss of calcium and phosphorus would presumably favor the formation of such stones. Perhaps the extent of the process in the first patient would suggest a disturbance of metabolism of longer standing, which would favor lithiasis.

The postoperative studies in the second case are interesting (Table III), as we may observe the transition from the hypercalcemia of hyperparathyroidism to the hypocalcemia of hypoparathyroidism. Obviously, however, the tests were not comparable to those made before operation, since the intake of calcium was many times greater (for the 24 hour period) than in the preoperative test, so that there was a disproportion between the intake of calcium and that of phosphorus.

As Shelling and Goodman³ have shown, it is important to meet the immediate reversal of function following parathyroidectomy by a diet low in phosphorus and high in calcium, which helps to guard against further depression of the calcium. While this is ordinarily accomplished by administration of calcium, we believe that a careful restriction of phosphorus is of additional benefit. Additional calcium was not given in the cases cited, as we desired a minimal intake in order to detect the endogenous (endocrine) factors.

This study illustrates remarkably well the shift of the excretion of calcium from urine to stool, and the change to a positive balance. That this is a temporary phenomenon must be admitted, since follow up subsequently has shown no persistent tetany and no hypocalcemia. We think it likely that a further study might show a readjustment to that of the normal adult metabolism.

In each of these two cases, an erroneous diagnosis of giant cell tumor was made, roentgenologically in one, and microscopically, after biopsy, in the other. There are certain differentiating points between giant cell tumor and the giant cell variant of osteitis fibrosa cystica. The former is usually situated asymmetrically at the epiphyses of the long bones; namely, the lower end of the radius and femur and the upper end of the tibia, and usually is single rather than multiple. The giant cell variant of osteitis fibrosa may occur in the shaft of the bone, subperiosteally or centrally, and is associated with generalized demineralization of the skeleton and altered calcium and phos-

phorus metabolism. This lesion is more likely to be multiple. Although there is some controversy concerning this differentiation by pathologic means, many contend that there is a difference in the stroma. If one includes a small portion of surrounding bone proper, in the biopsy, the histologic picture of osteitis fibrosa should be evident enough to suggest hyperparathyroidism in those cases of giant cell variant.

Both patients sought medical attention because of pathologic fractures. The patient with the more advanced demineralization of the skeleton, longer history, higher serum calcium level, and larger tumor, developed tetany after operation, while the other patient, having these characteristic findings in a lesser degree, did not develop signs of hypoparathyroidism. The first patient developed symptoms and signs of latent tetany on the second day after operation with a normal serum calcium level of 10.2 mg., indicating that a sudden drop in the amount of calcium in the serum may produce symptoms suggesting hypocalcemia in the same way that the sudden drop in blood sugar level may produce symptoms suggesting hypoglycemia in a patient with diabetes mellitus, even though the actual level is normal or above.

In each case, the symptoms and signs rapidly disappeared following the removal of the parathyroid tumors, and a deposition of minerals in the skeleton took place within a short time. A markedly negative calcium balance became positive after parathyroidectomy, indicating that reconstruction of the skeleton was taking place. In time, a normal negative balance may be expected to supersede this. The outstanding symptoms of easy fatigability underwent the most marked subjective improvement.

DISCUSSION.—There are three important types of parathyroid hyperfunction (exclusive of that caused by malignant tumors): the adenomatous, the hyperplastic associated with renal calculus, and the secondary, compensatory hyperplastic type. Only in the first two is parathyroidectomy indicated.

In 1907, Erdheim,⁴ by experimental and anatomic means, demonstrated the enlargement of all the parathyroid glands in osteomalacia. He concluded that this enlargement was of a secondary, compensatory nature—that is, a result, rather than a cause, of disease of the skeleton. It was found later that this secondary parathyroid hyperfunction was associated with other types of diseases of the skeleton, such as arthritis, osteitis deformans, multiple myeloma, metastatic carcinoma and rickets, as well as scleroderma and nephritis. We had the opportunity to study a young patient with renal rickets who, at autopsy, showed the same type of hyperplasia of all the parathyroid glands.⁵

In the consideration of hyperparathyroidism associated with generalized osteitis fibrosa cystica, a careful distinction must be made between this secondary, compensatory parathyroid hyperplasia and parathyroid adenoma. Parathyroid enlargement, with resulting hyperparathyroidism, may be either hyperplastic or adenomatous. Hyperplasia affects all the tissue, but an adenoma usually involves only one, or at most two, of the glands. It seems logical to assume that hyperplasia, therefore, is dependent upon an external

stimulant while an adenoma is the result of local factors caused by neoplastic growth.⁶

In 1925, Mandl⁷ removed a large parathyroid adenoma from a patient who thereafter obtained marked clinical improvement in the skeletal symptoms and signs of generalized osteitis fibrosa cystica. Following the report of this operation, parathyroidectomy was performed for many of the previously named conditions, until it was established that generalized osteitis fibrosa cystica is the only one of these diseases caused by a parathyroid adenoma. Microscopically, Mallory and Castleman⁶ differentiated hyperplasia from adenomatous enlargement. They found the chief cell, or one of its transition, to be the important constituent of the adenoma associated with hyperparathyroidism in the majority of cases.

Recently Albright⁸ discovered several cases of hyperplasia of the parathyroid glands by obtaining routine serum calcium and phosphorus determinations on patients with renal calculi. Those patients who showed a high serum calcium and a low serum phosphorus, though they showed no skeletal changes or elevation of the plasma phosphatase, were operated upon and enlarged hyperplastic parathyroid glands of different sizes removed. These patients improved following the removal of the main bulk of their parathyroid tissue. They seem to fall into a separate group from the secondary hyperplasias mentioned above. We have not encountered such a case nor any reports of similar cases from other clinics.

One should be familiar not only with the anatomic regions encountered in the ordinary thyroidectomy but also with the appearance, aberrant locations, and difficulties in locating tumors of the parathyroid glands. Roentgenologic evidence of deviation of the trachea or esophagus may aid in locating the tumor before operation. Walton,⁹ Churchill,¹⁰ and Lahey¹¹ have emphasized the importance of being prepared to make a thorough search in the retrotracheal and retro-esophageal planes of the neck, the lateral triangles of the neck, and in the anterior and posterior mediastinum. To overlook the tumor at the first operation may rob the patient of a chance for cure, because of the great difficulty in exploring the neck and mediastinum subsequently through a firm bed of scar tissue. We feel that, if a tumor is not found, removal of a normal parathyroid gland is not only without therapeutic effect but may be harmful. Likewise, we are skeptical concerning the removal of normal glands for many conditions alleged to result from parathyroid hyperfunction.

CONCLUSIONS

(1) Primary hyperparathyroidism is a clinical entity caused by one or more parathyroid adenomata and has a definite train of clinical, metabolic and roentgenologic findings. The diagnosis is based on a study of these three factors and not on any one alone. Primary hyperparathyroidism should not be confused with secondary compensatory parathyroid hyperplasia.

(2) The two cases reported show that the presence of malacic disease

in two members of the same family does not necessarily point to a diagnosis of fragilitas ossium or to any other type of familial skeletal disturbance.

(3) When a diagnosis of giant cell tumor is made by pathologic or roentgenologic methods, metabolic studies should follow.

(4) A conservative attitude should be taken concerning the removal of normal or hyperplastic parathyroid glands for a multiplicity of conditions.

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CYCLOPROPANE ANESTHESIA IN THYROIDECTOMY*

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FROM 1919 to October 23, 1935, in a series of goiter operations well in excess of 4,000 cases, nitrous oxide and oxygen (with or without ether) had become the anesthetic of choice in the Goiter Clinic of the Long Island College Hospital. In general, the patients were kept well under control. The postoperative recovery was, as a rule, quite prompt. Postoperative crises and acidosis were, for the most part, adequately controlled. Complications referable to anesthesia per se were indeed few and our mortality rate had continued downward.¹

Since October 23, 1935, we have, to a large extent, been using cyclopropane in goiter operations. Cyclopropane or trimethylene is a "ring" hydrocarbon first prepared by Freund in 1882. No use was made of the agent until 1929, since which time it has been finding increased application as an anesthetic of great value. An important experimental contribution appeared in 1934 from the University of Wisconsin.² Since this time cyclopropane has been found to be an extremely potent anesthetic with little evidence of immediate or delayed toxicity, if given in amounts not in excess of that necessary to produce surgical anesthesia. Cyclopropane, like ether, probably owes its anesthetic properties in part to its solubility in lipoids. It is inflammable and, like ether and ethylene, forms explosive mixtures with air and oxygen. Precautions are thus necessary.

Cyclopropane is said to have the potency of chloroform and ether without their irritant qualities and, except in very high concentrations, it is not measurably harmful to liver, kidneys or heart.³ A very high potency is necessary to produce spasm of the larynx. The anesthetist must guard against crowding the patient from the induction stage to the deeper stages of narcosis, since the usual laryngeal reflexes are not present to warn him. Cyclopropane does not stimulate respiration. In contradistinction to nitrous oxide and ethylene which produce an initial increase in the rate and volume of respiration and even depression from oxygen insufficiency, cyclopropane usually causes little if any change in the rate and volume of breathing unless concentrations greatly in excess of 20 per cent are used. The large amount of oxygen given with the gas prevents cyanosis and the blood thus constantly maintains a bright crimson color. It has been stated that capillary bleeding is increased by cyclopropane. In a small series of cases, we determined the coagulation and bleeding times before and at the end of operation and found no appreciable deviations from the normal. Other factors may of course be concerned in this matter. The

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impression of an apparent increased bleeding is doubtless based on the surgeon's continued visualization of a bright crimson operative field, and the notion has probably no real foundation in fact.

The method of administration has been that of the carbon dioxide absorption technic in a closed circuit. Expired carbon dioxide is retained in the soda lime. The oxygen consumed is replaced by a constant measured flow of oxygen equal to, or in excess of, the patient's requirements. We have not changed the premedication. Amytal (one and a half grains) is given the night before operation. An hypodermic of morphine— $\frac{1}{8}$ to $\frac{1}{6}$ of a grain—is given one hour before operation and repeated immediately before the patient is sent to the operating room. Too much preliminary medication tending to depress respiration is not advisable since cyclopropane is not a respiratory stimulant.

Only a few minutes are required to produce anesthesia with cyclopropane in the average patient with hyperthyroidism. Unusually nervous patients, especially those with high metabolic rates, require a greater induction time and larger concentrations of the gas. An initial potency of 5 to 10 per cent cyclopropane with 90 to 95 per cent oxygen is satisfactory in most cases and the operation can usually be continued with the lower limits of concentration. Recourse to ether as an adjunct to cyclopropane has not been found necessary in our experience. There is no excitement period and the various stages of anesthesia—induction to deep narcosis—are merged rapidly, but the patient is always protected by a large concentration of oxygen. Even passive breathing is compatible with safety. Unlike nitrous oxide, it does not produce choking, burning or strangling. It is pleasant to take. Recovery is rapid. Headache, disorientation and subjective symptoms are reduced to a minimum. Normal conscious reactions are quickly established and the patient can usually cooperate promptly. While postoperative nausea and vomiting occur, we believe that they are less prolonged than with other inhalation anesthetics.

We have been impressed by a peculiar mottled ruddiness of the skin of the body—notably the chest—that very quickly develops after the administration of cyclopropane. The phenomenon seems to be most pronounced in the cases of marked clinical activity and elevation of the B.M.R. It is probably the result of various factors such as the increased concentration of oxygen in the blood and the heightened vasomotor activity. The elimination of the cyclopropane in part by the skin may be an added factor.

In exophthalmic goiter with high metabolism, the patient's demand for oxygen is frequently so great that we have often had difficulty in maintaining a sufficient degree of concentration of nitrous oxide to prevent anoxemia and cardiorespiratory distress. Frequently ether had to be supplemented to obtain relaxation. Venous congestion during the operation was at times disturbing, the postoperative nausea and vomiting were increased, the normal postoperative conscious responses were delayed and acidosis and acetonuria were encountered more often.

Inasmuch as a large number of goitrous patients have varying amounts of

cardiac damage, a powerful anesthetic which per se has no serious toxic effects on cardiac muscle and which can be given without producing anoxemia and consequent overloading of the heart should have distinct advantages. Cyclopropane is such an agent. Most thyrocardiac patients demand more than the ordinary amounts of oxygen. Furthermore, high oxygen ratios protect the weakened myocardium against the strain of operation.⁵

Obstruction to respiration tends to labored breathing and oxygen insufficiency with obvious difficulties. In removing large adenomatous goiters, particularly those that have caused tracheal narrowing or compression, cyclopropane has proven to be very helpful. The tracheal reflexes are quickly abolished and sufficient oxygen can usually be supplied to prevent respiratory distress, venous congestion and asphyxia even with passive breathing. The quick abolition of the throat reflexes by cyclopropane is of great value when recourse to airways seems necessary, particularly in cases of partial obstruction or tracheal narrowing. With other forms of inhalation anesthesia, it is frequently very difficult to insert and maintain the tube on account of troublesome coughing and even vomiting. The resulting dyspnea, cyanosis and venous engorgement produce added difficulties. Anxious moments for anesthesiologists and operator alike have been less frequent since we have been using cyclopropane.

Because cyclopropane has not been found, experimentally, to depress liver and kidney function excepting when used in exceedingly high concentration, we have found it valuable in long standing cases of hyperthyroidism with hepatic and renal parenchymal damage.

Experimentally, cyclopropane and nitrous oxide were administered interchangeably for varying periods. The change from cyclopropane to nitrous oxide was usually quite noticeable. The respirations quickened and became more active and forceful, the blood became darker and the operative reactions were increased. Whenever nitrous oxide alone or in combination with ether proved to be annoying, a change to cyclopropane was usually promptly followed by calm and relaxation.

It is not within the scope of this brief report to outline our statistical data in great detail. There were only four postoperative developments worthy of mention.

(1) In a woman, age 36, pulmonary embolism and infarction followed almost immediately after operation for Graves' Disease. She continued acutely ill for 12 hours and then steadily improved. Recovery was complete.

(2) A man, age 29, presented an acute Graves' syndrome. Outstanding features were great anxiety and morbid fear of operation. The element of fear was doubtless concerned in a delayed but transiently critical postoperative reaction—a kind of atypical shock that remains unexplained. Recovery followed.

(3) A woman, age 51, suffering from a huge bilateral adenomatous goiter that had recently undergone malignant degeneration was submitted to a partial bilateral lobectomy under cyclopropane. Notwithstanding a prolonged opera-

tion with more than average loss of blood, the condition of the patient as based on the usual criteria, such as pulse, blood pressure and respirations, seemed compatible with safety. A moderately severe shock followed operation. Recovery followed. Study of this case suggests that "surcharging" the circulation, so to speak, with oxygen may at times obscure the real status of a debilitated patient. Such a patient's ruddy appearance may belie her real physical condition and the surgeon may be caught off guard and thus be led into a false sense of security.

(4) There was one fatality. A woman, age 66, who for many years had had a large bilateral adenomatous goiter causing tracheal narrowing, died in crisis 76 hours following operation. (Just how crisis is produced is difficult to say. It is doubtless a summation of a series of reactions involving the thyroid, adrenals and the sympathetic nervous system and precipitated by operative procedures—whether slight or extensive. It may follow after minimal procedures such as a single ligation under local anesthesia.) Critical study of the factors concerned in the fatal crisis leads us to believe that the result was in spite of, rather than because of, the cyclopropane. Incidentally, this was the first fatality in 447 consecutive operations for goiter.¹

From October 25, 1935, to April 6, 1936, 170 hyperthyroid patients were submitted to operation. Of these by far the greatest number, namely 111 patients, were given cyclopropane-oxygen anesthesia *alone* with generally very satisfactory postoperative results.

The second largest number, namely, 33 patients, were submitted to nitrous oxide-oxygen induction. Nitrous oxide-oxygen was continued, but varying amounts of ether had to be given to maintain satisfactory anesthesia.

The third largest number, namely, 14 cases, were given cyclopropane and nitrous oxide interchangeably in order to study comparative merits. The results were generally in favor of cyclopropane.

A fourth group, namely, eight cases, were given only nitrous oxide-oxygen anesthesia with very satisfactory results. These cases, for the most part, presented the milder degrees of hyperthyroidism.

Three cases were given avertin (basal) anesthesia followed by cyclopropane. One case was given local anesthesia (novocaine) plus cyclopropane.

Three cases were complicated by pregnancy. It is our feeling that pregnancy, particularly in the early months, does not contraindicate operation. On the contrary, we believe thyroidectomy insures a safer labor. In the past, we have held to the opinion that ether in combination with comparatively low concentrations of nitrous oxide was the anesthetic of choice. Nitrous oxide in large concentration was said to predispose to miscarriage especially in the presence of any considerable degree of anoxemia tending to fetal asphyxia. Our three cases made uneventful recoveries and there were no signs of threatened abortion.

In conclusion, we believe that a review of a series of goiter operations performed since October 25, 1935, has indicated that in cyclopropane we have a valuable aid in the facilitation of thyroidectomy. We are of the opinion that

nitrous oxide compares favorably with cyclopropane in the less active and uncomplicated cases of hyperthyroidism. However, in the acute cases with marked clinical activity, high metabolism and cardiac impairment, and in the chronic cases with obstructive difficulties, renal and hepatic parenchymal damage, cyclopropane will doubtless replace nitrous oxide and ether as the anesthetic of choice. Care should be exercised lest hyperventilation obscure the real status of a markedly debilitated or anemic patient. Also it must be borne in mind that hyperoxygenation may lead to unnecessary and annoying apnea. We are hopeful that with further study and experience, the favorable results of thyroidectomy will be further enhanced. Our anesthetists believe—as do we—that cyclopropane represents one more step in the approach to the ultimate, ideal anesthetic.

Note: Prolonged and disturbing apnea occurred once since the preceding report. A careful review of the data relating to the conduct of anesthesia leads us to believe that prolonged hyperoxygenation (with little or no cyclopropane) was the cause. Greater experience should obviate similar occurrences.

In our desire to prevent anoxemia and in view of the ease with which it can be prevented by increasing the oxygen concentration, we should not lose sight of the fact that high percentages of oxygen may of themselves prove toxic and furthermore that hyperventilation per se may lead to apnea.⁴ The resultant decrease in the carbon dioxide concentration in the blood may be depressed still further by continued hyperoxygenation and the respiratory center may thus lack the necessary stimulus to respond. A vicious cycle leading to prolonged apnea and even apapnea may thus result—the more the oxygen, the less the carbon dioxide concentration in the blood and consequently the greater and more prolonged the apnea. Even this circumstance, if recognized in time, need not necessarily prove dangerous inasmuch as respiration invariably fails before circulation.² When lack of experience or technical error lead to this annoying situation, removal of the mask and artificial respiration should promptly restore spontaneous breathing. Inflation of the lungs with carbon dioxide would occasionally seem indicated to cut short the continued apnea.

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THE PROBLEM OF MYOSITIS OSSIFICANS PROGRESSIVA

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THE study of myositis ossificans progressiva (Münchmeyer's disease), a condition occurring especially in boyhood, still presents many unknown problems. Recent researches of the calcium content of blood (Zieliński¹⁰) appear to demonstrate a close relationship with parathyroid activity, and the influence of the latter on pathologic bone formation points decidedly to an endocrine imbalance that gives rise to various morphologic conditions which are, no doubt, the result of a trophic degeneration.

From the histogenetic point of view it is a progressive bone metaplasia of different muscular groups, of the fasciae and of the tendons. Generally speaking, myositis ossificans progressiva commences by attacking the muscles of the neck, shoulders, and thoracic wall, as well as those of the trunk and mastication (Frejka,⁵ Guilbert,⁷ Westman,¹⁸ Hickel,⁸ Rinderman,¹² Fischer,⁴ Rouis,¹⁵ Magruder,⁹ Apert and Garnier,¹ Rocher,^{13, 14} Cassar and Jaubert de Beaujeu,² Masselot, Jaubert de Beaujeu and Bloch,¹⁰ Sàlat,¹⁶ Dobrzaniecki³). The localization in the lower parts of the body, such as in the rectus abdominalis, is most unusual. I have not found any instance of its having occurred in the muscles of the lower extremities. The smooth muscles of the vegetative organs and the striated muscles of the face, eyes, diaphragm, heart and of the sphincters, always remain intact.

In addition to the bone metaplasia one may also find abnormal cartilaginous exostoses which may form elastic tumors under the skin, and even serous bursae, representing true hygromata.

The disease may manifest itself very early in infancy, but rarely occurs in individuals over 20 (Apert and Garnier¹).

The prognosis is quite unfavorable on account of the limitation of movements, particularly those of mastication and respiration, which finally results in progressive cachexia.

There does not appear to be at present any appropriate treatment, either conservative or operative, although many attempts have been made such as the use of roentgen therapy (Nové-Josserand and Horand, Mucklow,¹¹ Schinz-Baensch-Friedel¹⁷), diathermy, treatment by mesothorium and hot air, internal acidifying treatment (Froehlich), fibrolysin, potassium iodide and recently parathyroidectomy (Rocher and Mathey-Cornat¹⁴), endocrinotherapy (Gorlitzer⁶) and removal of calcium from the food.

Based upon the literature we do not believe this disease to be hereditary, as some authors maintain; but it is certain that it has some predilection to males.

In certain cases one finds, in the anamnesis, the occurrence of syphilis in the parents, in other cases a concomitant tuberculosis.

Case Report.—A boy of four and one-half years was admitted to the hospital because of the abnormal position of his head, which had previously been diagnosed as torticollis. The parents could not state exactly when the condition had begun. The inclination of the head, however, had appeared eight months before. The physical and psychic state of the child was distinctly impaired.

The skin and the mucous membranes were pale. The abnormal position of the head



FIG. 1.—Inclination of the head towards the sternum with slight rotation to the right resulting from the ossification of the muscles of the nape of the neck. (Claude Bernard, Horner's syndrome of the left eye.)



FIG. 2.—On the nape of the neck is seen a protuberance extending archwise from the occiput on the right to form one mass with that on the thoracic. On the opposite side the protuberance commences at the level of the third rib and is less marked. These major masses are covered along their course by multiple exostoses.

was striking (Fig. 1), but it differed considerably from that of an habitual torticollis. It remained inclined downwards, with the chin fixed to the sternum, and it was impossible to obtain any movements of the head, either actively or passively, as the skull and the vertebral column were apparently rigidly fused. There was also an intense constriction of the jaw, which we were inclined to attribute to a process of a commencing myositis, as the roentgenologic examination of the temporomandibular articulation and of the muscles of mastication showed nothing that could explain the trismus in any other way. The configuration of the face was symmetrical. The left eye showed a very distinct Claude Bernard-Horner syndrome.

Deep palpation of the neck did not disclose any tumefaction of the parathyroids.

On the nape of the neck a protuberance could be seen that extended from the occiput on the right side to the thoracic tumefaction on the same side. On the opposite side the

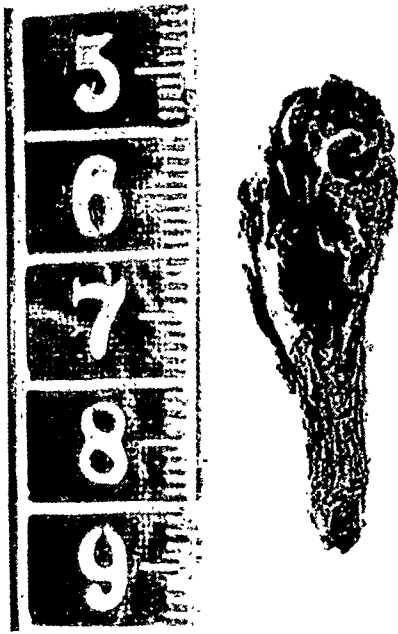


FIG. 3.—The cartilaginous exostosis removed with a fragment of a newly formed bone for microscopic examination.

tumor which commenced at the level of the third rib was less distinct. These major masses gave rise to a lateral tumor (Fig. 2). They were all easily palpable, of a bony consistence, and contained many excrescences of different dimensions which gave one the impression of cartilage. These exostoses were firmly attached to the deeper structures. One of them was removed (Fig. 3) together with a newly formed bony fragment for microscopic examination, which showed a normal cartilaginous bony structure with a medullary canal.

There were other developmental anomalies present. The thumb was brachydactylic inasmuch as it showed a reduction in its length. The feet were flat, and the toes were in the position of the hallus valgus.

Roentgenologic Examination.—The skull and sella turcica were normal. The feet showed moderate widening and elongation of the shafts of both first metatarsal bones, with quite pronounced thinning of the cortex and increased lamellation in the medullary area.

The course of these trabeculae deviates from that of the normal trabeculation; some



FIG. 4.—Roentgenogram of the feet, showing the toes in hallus valgus position, and the increased lamellation in the medullary area of the first metatarsal. The lack of distinct differentiation between the compact and the cancellous tissue may also be noted.



FIG. 5.—Anteroposterior roentgenogram of the neck and thorax.



FIG. 6.—Lateral roentgenogram showing the ramifications in the thoracic muscles and along the vertebral column.

FIG. 7.—Roentgenogram showing a detail of the synostosis of the cervical ossification with the occiput.

FIG. 8.—Roentgenogram showing a detail of the lumbo-sacral ossification.

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appear thicker than normally. The remaining metatarsals, with the exception of the second and third left, and also all the tarsal bones, present similar structural changes to a lesser degree (Fig. 4). There is no distinct differentiation between the compact and the cancellous tissue. The distal ends of both first metatarsals present a deformity resembling an epiphysis, which, however, is not normally present.

A tuberculous subclavicular focus was evident in the apex of the left upper lobe of the lung.

The anteroposterior roentgenogram of the neck and thorax was most instructive as far as the anatomic disposition of the ossifications was concerned (Fig. 5). Generally speaking, these formed two large masses along the vertebral column, beginning on the left side from the third thoracic vertebra and on the right from the occiput where they formed the true synostosis. The ossified streaks extended as far as the iliac crests. Thus the process affected all the muscles of the nape of the neck and an entire mass of the dorsolumbosacral group. These ossifications continued, through their ramifications, to the thoracic muscles. In three places the new ossified formations presented buds of articulations, either among themselves or with the vertebrae (Figs. 6, 7 and 8). A composite tracing made from the roentgenograms gave us an exact insight into the dimensions and the courses of the ossified muscles (Fig. 9).

In addition to these disturbances there were also found on the internal border of the proximal diaphysis of the humerus and of the left tibia, formations similar to osteogenic exostoses.

The Bordet-Wassermann reaction was negative. The calcemia indicated by the Kramer-Tissdal method was 19.5 milligrams per cent (normal 7.9 milligrams per cent). The urinalysis was normal.

We contemplated, primarily, making an exploratory incision in the neck in order to examine the parathyroids. This, however, was impossible, owing to the position of the head, as the jaw completely covered the anterior surface of the neck. We therefore

restricted ourselves to roentgen therapy of the parathyroids. On examination of the calcium content of blood three months later, the recovery of 19.67 milligrams per cent showed that the calcemia had been maintained at its original level.

During the course of the child's illness there persisted a continued elevation of the temperature, which reached a maximum of 39° C. This lasted for two weeks without any positive clinical sign that would explain it. We were inclined to attribute it to the tuberculous subclavicular focus which had been disclosed by the roentgenologic examination.

The child remained under our observation for three months, during which time the disease made further progress in the muscles of the thoracic wall and of the lumbar region.

We must admit here that the term "myositis ossificans progressiva" is not very rightly chosen, if we consider this affection as a constitutional anomaly,

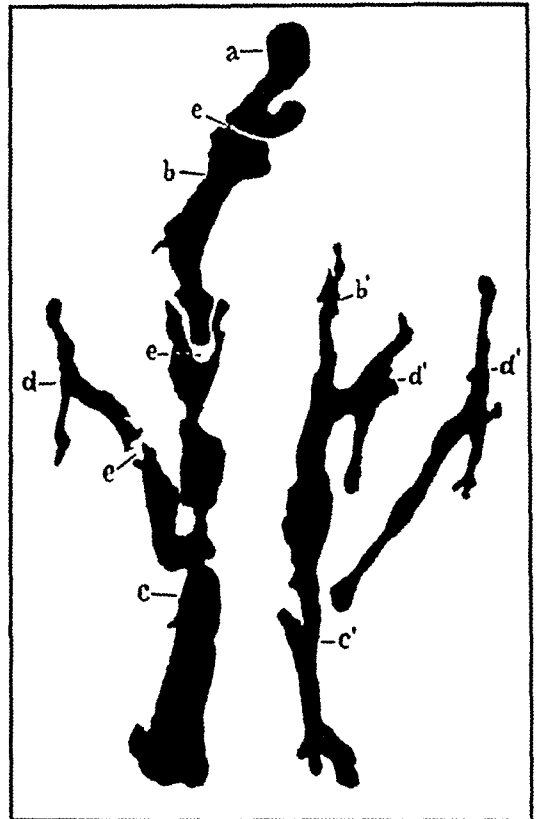


FIG. 9.—A composite tracing of the roentgenograms showing the dimensions and the course of the ossified muscles. (a) Cervical ossification, (bb') Ossifications along the vertebral column, (dd') Ramifications in the thoracic muscles, (cc') Lumbosacral ossifications, (e) Buds of articulations.

or as an osteoformatory aberration, a hormonal disturbance or a vicious differentiation of the mesenchymatous elements. The term myositis is therefore inexact and requires a revision in order to more correctly adapt it to the present ideas concerning this disease.

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DIVISION OF RIBS AS AN AID IN CLOSING A DIAPHRAGMATIC HERNIA

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IN HEDBLOM's reviews^{1, 2} reference is made to thoracoplasty as a preliminary to the repair of large defects or congenital absence of the diaphragm on the left. Carrington³ and Harrington⁴ appear to have been the first to carry out this two stage technic. No doubt, also, the simple section or resection of small segments of the lower ribs at the time of operation has been made use of to accomplish a less complete collapse of the thoracic cage, but, although the rationale seems obvious and the procedure itself surprisingly simple, I am unable to find the record of more than two cases in which the maneuver has been utilized. These were reported by Bettman and Hess,^{5,6} who in 1929 and 1931 successfully operated upon infants of three and one-half, and nine months, respectively, by their original technic.

In my own case, the repair was made so much more simple and secure by removing small segments of the ninth, tenth and eleventh ribs that I am sure similar cases can be benefited by use of the method. This feeling is substantiated by descriptions in the literature of cases in which recurrences of peripheral defects in the diaphragm were ascribed to inability to close satisfactorily the portions which lay next to the ribs. In some of these cases the section and inward displacement of the ribs would undoubtedly have led to success.

In the case cited, the ribs dropped inward, thus releasing tension so that the mattress sutures of braided silk which had been placed in the diaphragm could be tied without undue strain, and so that the outer arms of the defect could be sutured securely to the displaced ribs, completing the closure (Fig. 6a, b, c).

Case Report.—J. S., a boy, age eight, had been observed by members of the pediatric service since the age of three. His birth and early development were normal, but when he was two and one-half years old he fell about eight feet to the ground from the top of a shed, striking forcibly on the left side of the body and fracturing the left forearm. The child was quite ill and somewhat short of breath for a few days after this accident, but attention was paid for the most part to the broken arm. There were no gastrointestinal symptoms until six months later when the child was admitted to the pediatric ward because of vomiting, indigestion and diarrhea. Investigation revealed a dextrocardia and an abnormality of the left chest which was at first interpreted as chronic empyema (Fig. 1). However, peristaltic sounds were heard and roentgenologic examination demonstrated the presence of loops of bowel in the left pleural cavity (Fig. 2). When filled with barium, the stomach was seen to be large and atonic (Fig. 3), and a

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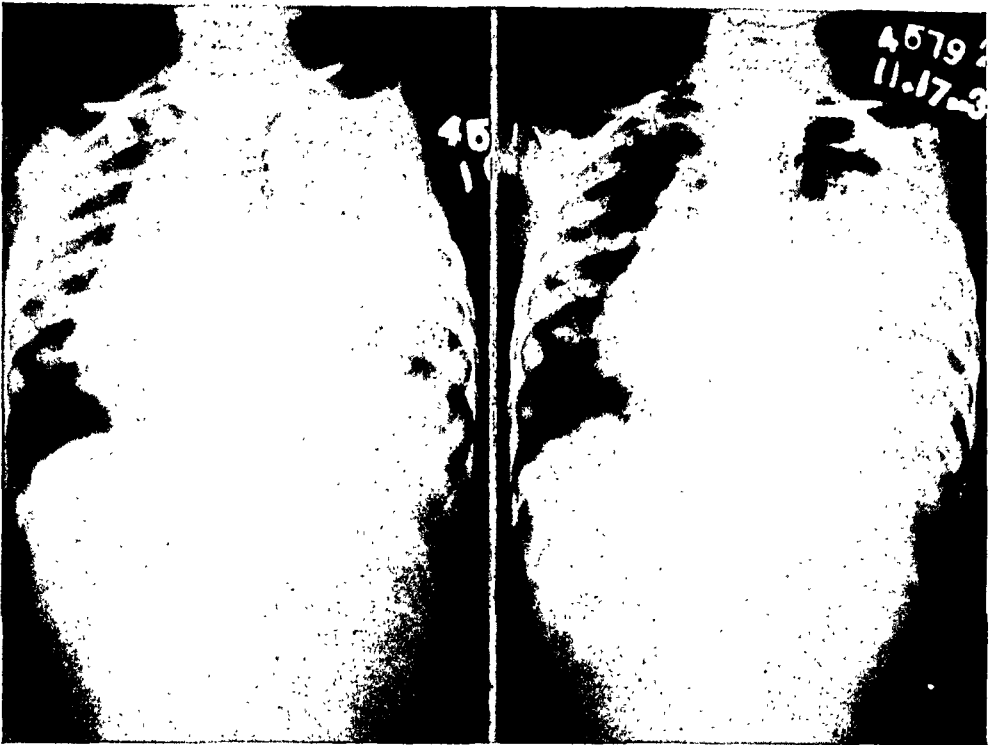


FIG. 1.—Original roentgenogram at the age of three.

FIG. 2.—Roentgenogram taken a few days after that shown in Fig. 1, in which the loops of bowel are more evident.

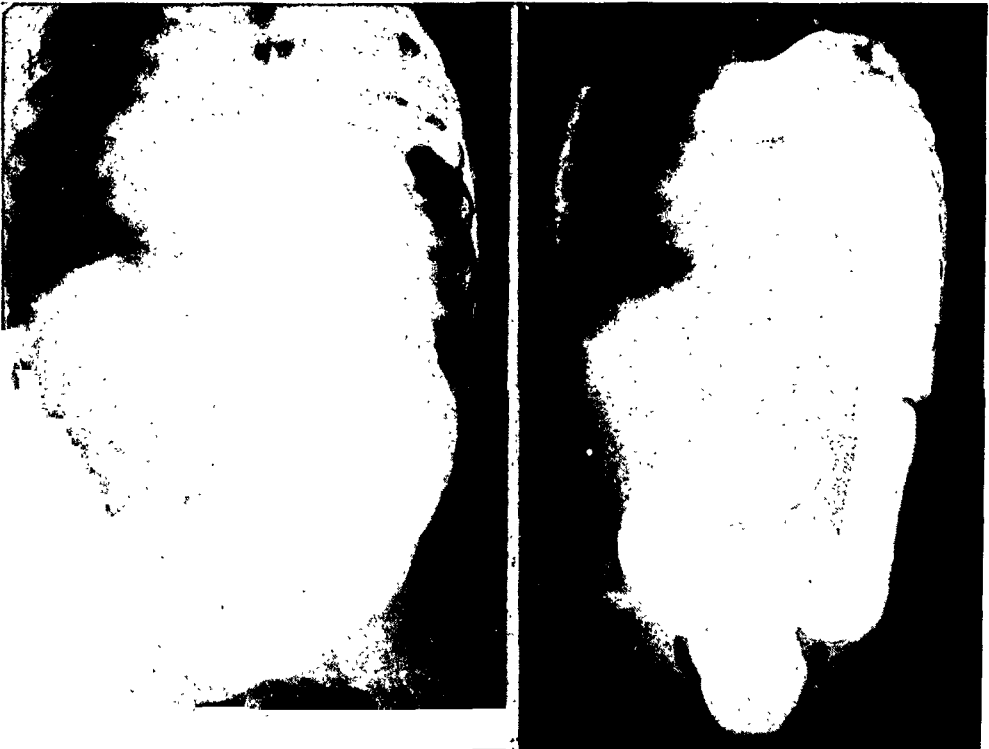


FIG. 3.—Dilated, atonic stomach. (This dilatation of the stomach was important because it kept the peritoneal cavity large enough to receive the intrathoracic viscera at operation.) No evidence of small intestines in the peritoneal cavity. Gas in colon indicates site of hernia in diaphragm.

FIG. 4.—Barium enema showing colon high in the left thoracic cavity. In a lateral film, narrowing of the lumen was seen at the orifice of the diaphragmatic defect.

barium enema showed that a large part of the otherwise normal appearing colon was above the diaphragm (Fig. 4).

The child's indigestion and diarrhea ceased and he was discharged much improved. From this time on, however, he was in and out of the hospital and dispensary repeatedly, once with measles, but usually with mild or severe upper respiratory infections or mild colic and vomiting accompanied by diarrhea. The symptoms always subsided quite promptly when he was put to bed, but he remained somewhat thin, frail and undersized. The mother was advised in 1932 that an operation should be performed, but it was not until after a rather severe attack of obstruction in 1935 that she consented.

Fortunately, this acute attack subsided. Further roentgenologic examination then showed that during the five years since the original studies the left lung had expanded somewhat, and the heart had approached the midline (Fig. 5). The stomach still hung low in the pelvis, but was less atonic. No loops of small bowel were ever visualized in the abdomen. A barium enema showed the colon situated as formerly with all of it, except the sigmoid and descending arm, in the left thoracic cavity.

Operation: Preliminary Abdominal Exploration.—In order to determine the exact relations of the viscera within the abdominal cavity, an upper left rectus incision was made under ether anesthesia July 10, 1935. The stomach was atonic and filled a large portion of the abdominal cavity. The edge of the liver lay just above the level of the umbilicus. A Levine tube was passed and through it the stomach was emptied of gas so that it was possible to displace it and thus visualize the other abdominal viscera. The rectum, sigmoid and descending colon extended straight from the pelvis to the lateral portion of the left leaf of the diaphragm where the colon entered the thoracic cavity. The spleen was nowhere to be seen and a large part of the omentum was in the thorax.

On observing the stomach more carefully, it was seen that the fundus was just below the hernial orifice, while the body hung low into the false pelvis, and the pylorus was hooked up high under the liver. The duodenum extended straight upward to the medial edge of the defect in the diaphragm; only about 8 cm. of the duodenum were within the abdominal cavity, and no other small bowel was to be seen. The gallbladder was normal except for a slight, apparently recent, low grade plastic peritoneal reaction which involved the visceral and parietal peritoneal surfaces here and elsewhere throughout the upper abdomen. The kidneys were normal in size and position, but the pancreas was pulled upward toward the hernial orifice, which was placed laterally and measured approximately 8 by 6 cm. The end of the ellipse which lay against the wall of the chest was somewhat broader and more firmly fixed than the narrower internal end which was not far from the esophageal orifice. The adhesions of omentum and bowel to the under surface of the diaphragm were not extensive. There was no adverse reaction to this exploration.

Secondary Thoracic Procedure.—Three days later, again under ether anesthesia, the thorax was opened through the eighth intercostal space. The spleen was encountered



FIG. 5.—Roentgenogram made at the age of five, before operation. The lung has expanded somewhat and the heart is nearer the midline. (Compare with Fig. 1.)

immediately and was found covered with the same thin, plastic exudate which we had noted in the abdomen. The ribs were spread widely, and the hernial orifice in the diaphragm was palpated. It lay against the wall of the chest in the anterior axillary line and extended toward the esophagus. Through it passed bowels and omentum. There was no peritoneal sac. The entire small bowel and the proximal half of the large bowel and the spleen were intrathoracic. The lung could be seen at the apex of the pleural cavity, small and covered by thickened pleura. The viscera were somewhat suspended in the thoracic cavity by numerous adhesions which were carefully separated by sharp and blunt dissection. A few were divided between ligatures.

The defect of the diaphragm was outlined by sharp dissection and the hand was passed into the abdominal cavity to make sure that reduction of the viscera would be made directly into the free peritoneal cavity. The spleen was first reduced, followed by the large and then the small bowel. It was necessary to increase the size of the opening by a medial incision in order to accomplish reduction. Even then the last portion of the small bowel was replaced with difficulty and had to be held in place by Mikulicz pads while the repair was carried out. The left phrenic nerve was not seen and the diaphragm did not move with respiration. Nevertheless, the musculature of the diaphragm was not atrophic and was well nourished.

The opening which had to be closed measured about 8 cm. in length and 6 cm. in width. At the medial end of the defect there was no difficulty in placing and tying mattress sutures of heavy braided silk, producing an overlap of at least 1 cm., but on progressing toward the ribs the diaphragm became more and more fibrous and fixation of the scar to the ribs made an unbridgeable gap of almost 5 cm. By retracting and freeing the soft tissues, the ninth, tenth and eleventh ribs were exposed slightly posteriorly to the defect in the diaphragm and segments about 1 cm. long were excised subperiosteally from each of them. It was now easy to foreshorten the wound in the diaphragm by passing braided silk sutures around these freed ribs and by suturing the diaphragm firmly to them up to a point where the original overlap could be made secure. The repair was thus made in a T-shaped manner and the central sutures passed through the outer end of the 1 cm. overlap (Fig. 6a, b, c). Interrupted figure-of-eight sutures of fine silk were placed to tack down the free edge of the diaphragm. The cavity in the chest seemed quite large and the lung, which measured only about 5 by 8 cm., showed no tendency to expand. The pleura over it was thick and white and there were several firm adhesions connecting its upper portion to the cupola of the pleura. It seemed best not to disturb these adhesions because the dissection would have to be done at the ends of long instruments and should any difficulty in hemostasis be encountered the bleeding would be difficult to control. Then, too, the child could not stand safely any further operating. The chest wall was closed hermetically by circular approximation of the two ribs adjoining the wound followed by careful suturing of the fascial layers with silk.

Stained smears and cultures of the plastic exudate found over the spleen showed no organisms.

The convalescence following this rather extensive replacement of viscera and closure of the diaphragm was surprisingly smooth. A transfusion of 250 cc. of blood was given immediately postoperative and fluids were provided in adequate amounts by mouth, subcutaneously and intravenously during the following days. There was no occasion to aspirate air from the left pleural cavity; however, as has been pointed out by many writers, this should be done in most cases immediately after the chest is closed. An oxygen tent was unnecessary. The intranasal Levine tube used at operation was left in place with constant negative pressure applied to keep the stomach and upper bowel free from gas. Castor oil and eserine were given to promote peristalsis, and the patient expelled gas through a rectal tube the day after operation.

The roentgenogram shown in Fig. 7 was taken on the sixth postoperative day when the temperature was 98.4° F., pulse 80, and respirations 20. There was no distress in spite of the shift of the heart to the right, apparently because the child had adjusted him-

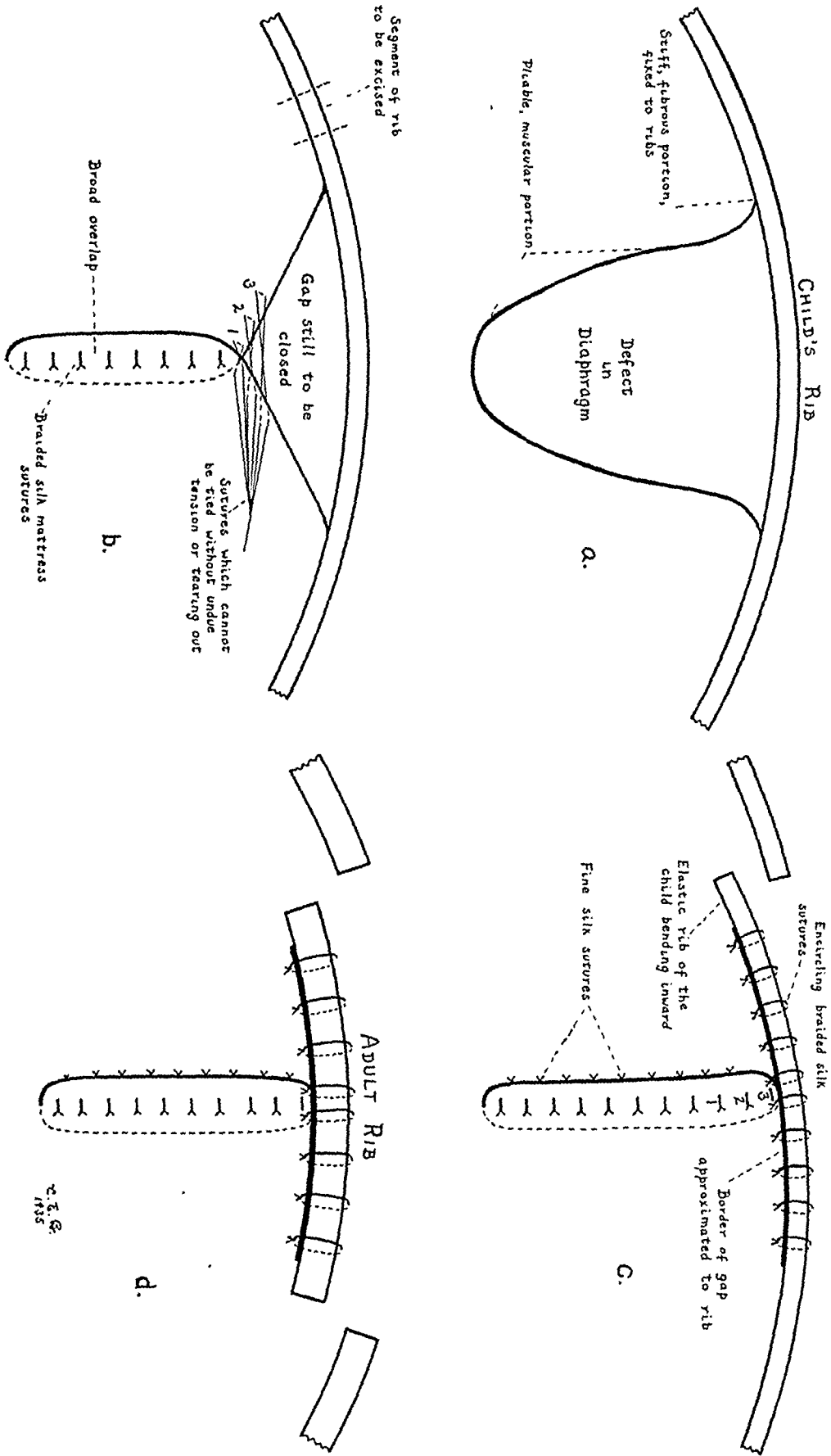


FIG. 6 (a, b and c).—Shows the successive steps in the closure of the defect in the diaphragm in the author's case; (d) suggested technic for adults whose ribs are less yielding. In children one segment is removed from each rib; in adults two segments are excised. It will be recognized that the figures are diagrammatic and that, due to the obliquity of the ribs in relation to the periphery of the diaphragm, it is necessary to remove segments from at least two ribs in order to obtain the desired relaxation. Furthermore, of course, the diaphragm is sutured to two or three of the mobilized ribs instead of one.



FIG. 7.—Roentgenogram made on the sixth postoperative day. There was no respiratory distress and the temperature and pulse rate were normal. The figure shows the overlapping ribs (9, 10, 11) from which segments were removed and to which the diaphragm was sutured.

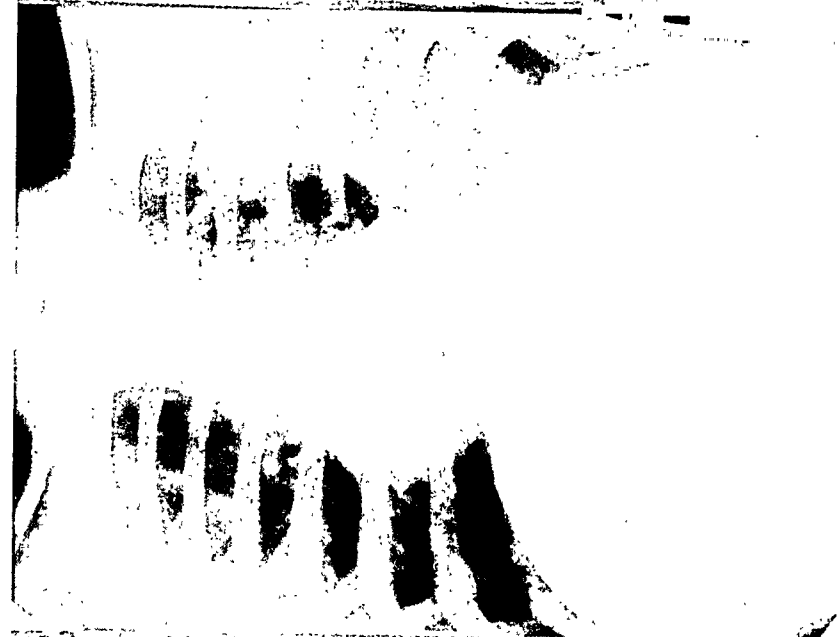


FIG. 8.—Three weeks after operation. The lung is expanding slowly and the heart is returning to the left side of the thorax.



FIG. 9.—Four months after operation. Further expansion of the lung. Heart pulled over to the left.

self to a reduced vital capacity over a period of years. The roentgenogram shows well the three displaced ribs from which short segments were taken in order to allow satisfactory closure of the diaphragm without undue tension. The thoracic wound healed cleanly.

Subsequent studies with barium by rectum and by mouth showed the colon, stomach and small bowel to lie in slightly bizarre relationships, but their functions were normal. A month after operation the child ate five green apples and a peach and gave everyone

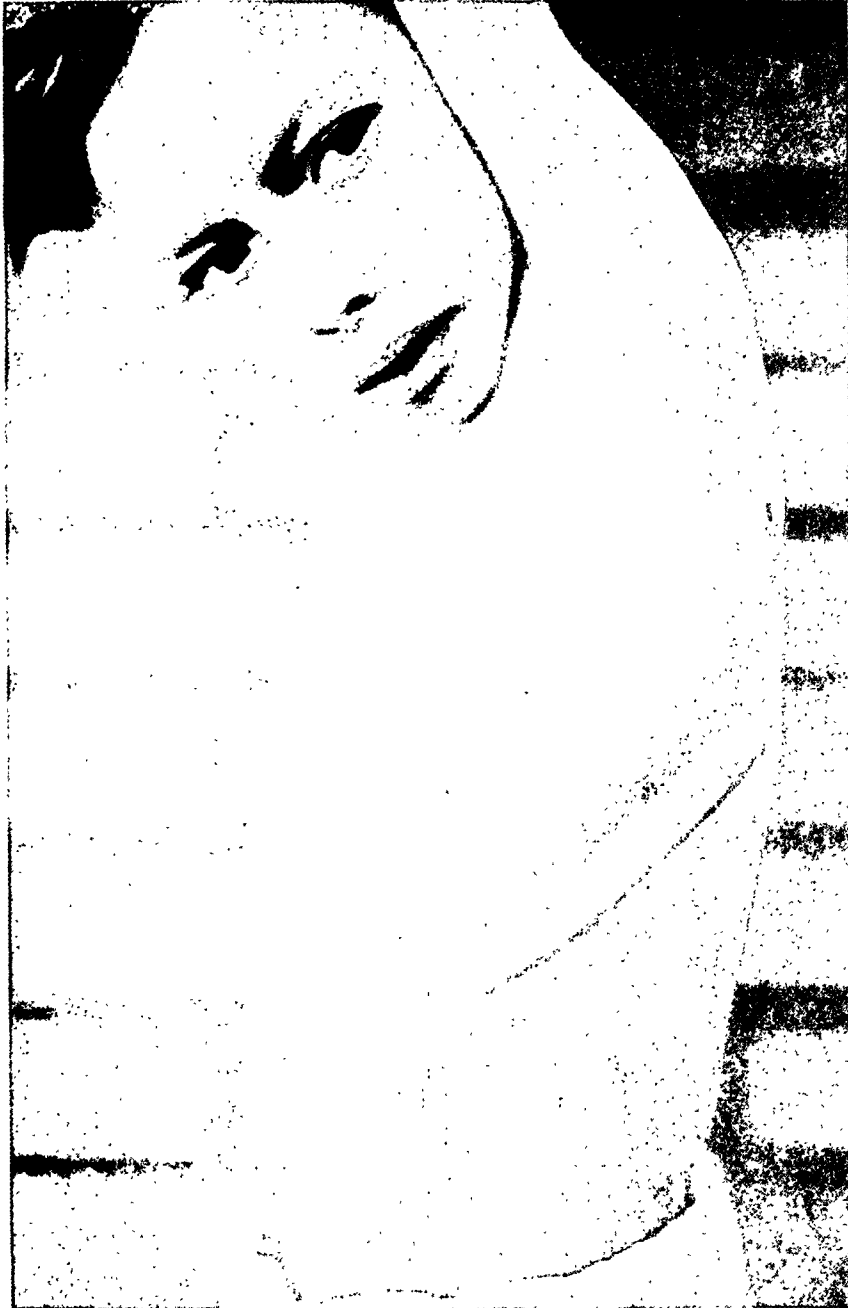


FIG. 10.—The photograph shows the thoracic incision through which the repair was carried out.

a scare because of colic and vomiting, but otherwise there has been nothing to suggest intestinal obstruction or recurrence of the hernia.

A roentgenogram of the chest taken three weeks after operation showed beginning expansion of the left lung, also density indicative of fluid in the pleural cavity (Fig. 8). Postero-anterior (Fig. 9) and lateral films taken four months later indicate that the lung is expanding slowly in spite of the thickened and adherent visceral pleura, and the probability is that expansion will be complete within a short time. The vital capacity is 1,000

cc. when lying down, and 1,200 cc. when standing up. The child's mother says that whereas formerly he never ran and played because of shortness of breath, he now runs upstairs without dyspnea and plays normally. She has noted also that previously the thorax appeared full and the abdomen usually flat. Now the left chest is slightly depressed and the abdomen is rounded (Fig. 10). The child's weight has increased from 40 to 47½ pounds during the six months since operation.

CONCLUSIONS

The simple maneuver of mobilizing two or three of the lower ribs is useful whenever the diameter of the lower thoracic outlet must be diminished in order to close a defect of the diaphragm satisfactorily. This is easily accomplished in children. In older patients, whose ribs are unyielding, the removal of two short segments from each rib, one segment anterior to the defect and the other posterior, will allow the ribs to drop in sufficiently, without damage to intercostal vessels, nerves or the pleura, to effect a repair in some of the difficult cases (Fig. 6d).

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DIVERTICULA OF THE VERMIFORM APPENDIX

A STUDY BASED ON THIRTY CASES

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It is becoming increasingly more apparent that diverticula of the vermiform appendix should merit more than mere academic interest on the part of physicians. Acute inflammation occurring in an appendix containing such diverticula is commonly followed by rapid perforation through the diverticulum with a subsequent generalized peritonitis after only a very few hours of atypical abdominal signs and symptoms. Mucocoeles developing in appendices that possess diverticula quite commonly perforate and cause pseudomyxoma peritonei. The data embodied in this study have been collected during the past ten years.

Appendiceal diverticula may be classified into two groups; the congenital or true and the acquired or false. Congenital diverticula are rare. The walls of such a diverticulum contains all the normal histologic components of the appendiceal wall. This group either develops during the growth of the fetus or before inflammatory changes make their appearance in the appendix. Edel, in 1894, reported one of the first examples of this type. The second type, or acquired false diverticulum, is commonly referred to as the inflammatory type, because it originates secondary to a preceding appendicitis which has left in its wake stenosing scars that cause varying degrees of lumen occlusion. The efforts of the muscularis of such an appendix to empty its lumen commonly lead to marked increase of the intraluminal pressure which in turn causes, occasionally, the herniation of the mucosa out through areas of lessened resistance in the muscularis which are the vascular hiati. Thus, the walls of the acquired or false appendiceal diverticulum are only composed of mucosa, some loose areolar tissue and the serosa. Therefore, the mechanism for sudden perforation during the acute inflammation of such an appendix is apparent.

The following is a brief review of some of the important contributions made upon this subject in the past: Villar³⁵ (1819) described an instance of perforation of an appendiceal diverticulum with the subsequent formation of a generalized pseudomyxoma peritonei. Excellent pathologic descriptions were presented by Rokitansky²⁹ (1842), Gähtgen⁹ (1853), and Virchow³⁶ (1863). Heschl¹⁵ (1880) experimentally reproduced false diverticula of the intestine by removing portions of dead human intestine and distending them with water under increased pressure. He found that small areas of bulging could be observed to occur along the mesenteric border which again

disappeared when the water pressure was reduced. Heschl believed, therefore, that obstruction plus increase of internal pressure in a hollow viscus were the two chief factors responsible for false acquired diverticulum formation. Hansemann¹³ and also Grassberger¹¹ (1897) independently confirmed Heschl's observations. Weinberg³⁹ (1898) presented his thesis upon the histologic lesions and common types of appendicitis. In this study, he discussed diverticula formation. He considered that they arose following repair of the mucosa after deep ulceration of the muscularis had occurred. It was his belief that either perforation occurred; or if the process stopped short of actual perforation, a diverticulum of the wall might be the result. Chlumsky⁶ (1899) proved that Heschl's (1880) experiments were invalid, because he had used dead intestine. When Chlumsky repeated this work using living dog intestine, acquired diverticula formation did not occur along the mesenteric border. When the excessive internal pressure finally burst the loop of intestine, it always occurred along the antimesenteric surface. Beer⁴ (1904) substantiated Chlumsky's claims.

Mertens²³ (1902) maintained that diverticula formation in the appendix occurred in the region of the vascular passages through the appendiceal muscularis. He believed in the presence of acute appendicitis, that rapid perforation with few symptoms could happen in such a diverticulum. The straining attendant upon defecation was also thought to occasionally rupture an appendiceal diverticulum. Mundt²⁶ (1903) concluded that diverticula of the appendix resulted from a circumscribed local infection of the appendiceal wall with destruction of the muscularis. After healing this gave rise to an extrusion of the mucosa through the appendiceal wall. It was his opinion that inflammation was the chief etiologic factor in the causation of appendiceal diverticula. Hedinger¹⁴ (1904) reported an instance of a congenital diverticulum of the appendix which was present in a full-term stillbirth consequent to a protracted labor as the result of a hydramnion and a transverse presentation. The distal third of the appendix was studded with numerous varying sized diverticula. Microscopic examination showed that these were of the congenital type and that the crypts of Lieberkühn showed increased branching with an accompanying tall and cylindrical mucosal epithelium. Von Brunn³⁷ (1905) and Seeling³¹ (1906) added six examples of acquired diverticula to the literature. Seeling's case was noteworthy because the diverticulum extended through a vascular hiatus in the muscularis. Maale¹⁹ (1908), in a small carefully studied group of appendices, was able to find eight additional examples of the inflammatory type. MacCarty and McGrath²² (1911) from their study found that appendiceal diverticula were usually multiple. Fifty-six per cent of their cases were derived from instances of acute appendicitis. The average age at operation in this series was 34 years with the extremes varying from 18 to 64 years. The average duration of symptoms had been seven years. Krabbel¹⁷ (1912) stated that

PLATE 1.



I.
6.8 X 5.1 CMS.
♂, 41.
Early Acute
Appendicitis.



II.
8.8 X 2.0 CMS.
♂, 31.
Acute Appendicitis
Mucocoele, Pseudo Myxoma
Peritonei.



III.
5.1 X 1.0 CMS.
♂, 45.
Acute Gangrenous
Appendicitis.



IV.
10.0 X 0.8 CMS.
♂, 30.
Acute Appendicitis.



V.
7.0 X 1.0 CMS.
♂, 27.
Acute Perforative Appendicitis.

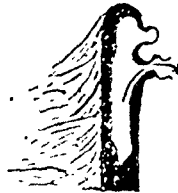


VI.
7.5 X 0.8 CMS.
♂, 14.
Chronic Appendicitis.

PLATE 2.



VII.
6.2 X 1.3 CMS.
♂, 30.
Acute Appendicitis.



VIII.
8.0 X 1.5 CMS.
♂, 49.
Pseudo-Myxoma-
Peritonei-Mucocoele.



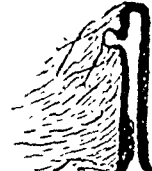
IX.
6.4 X 1.4 CMS.
♂, 33.
Chronic Appendicitis.



X.
4.0 X 0.7 CMS.
♂, 51.
Subacute
Appendicitis,
Carcinoid Tumor
of tip.



XI.
11.4 X 1.6 CMS.
♂, 64.
Chronic Appendicitis.



XII.
7.2 X 0.9 CMS.
♂, 32.
Subacute Appendicitis.

PLATE 3.



XIII.
8.8 X 1.1 CMS.
♂, 37.
Acute Perforative
Appendicitis.



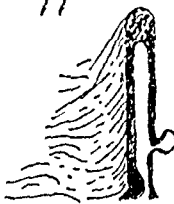
XIV.
9.7 X 1.3 CMS.
♂, 43.
Early Acute
Appendicitis.



XV.
6.1 X 1.2 CMS.
♂, 41.
Acute Gangrenous
Appendicitis.



XVI.
6.1 X 1.1 CMS.
♂, 43.
Acute Appendicitis.



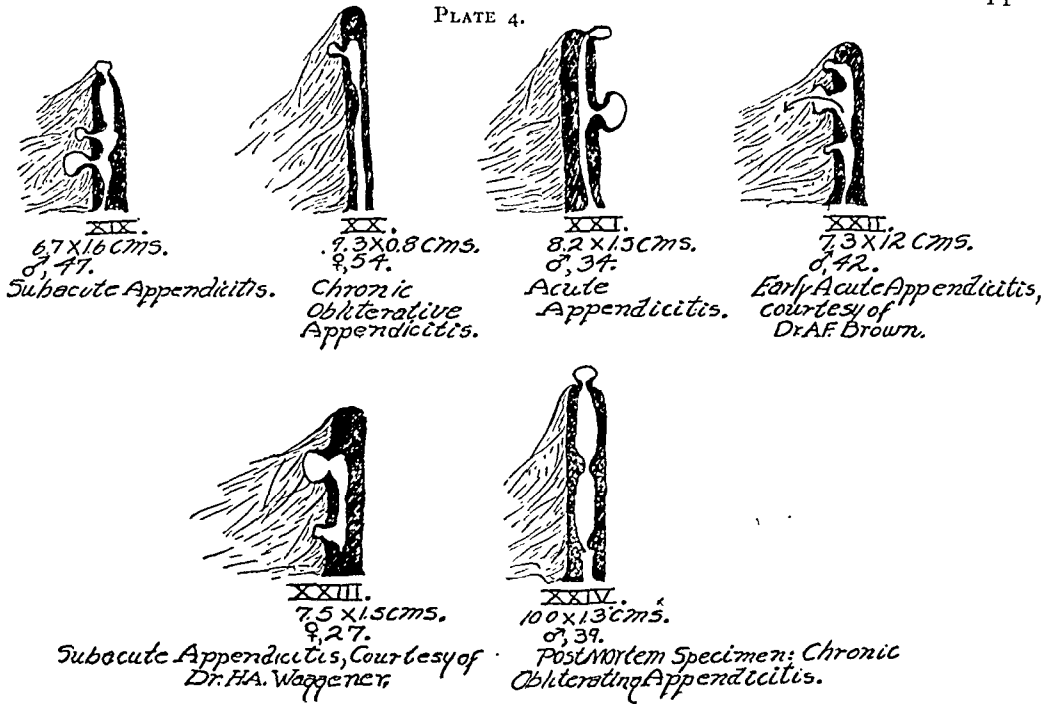
XVII.
7.9 X 0.9 CMS.
♂, 39.
Chronic Appendicitis.



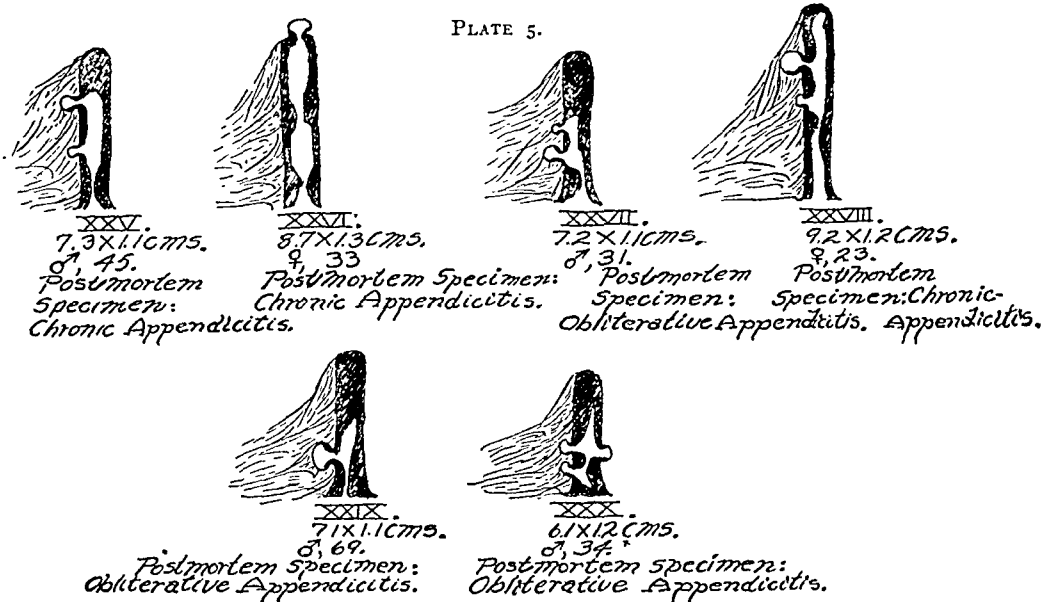
XVIII.
8.1 X 1.0 CMS.
♂, 28.
Mucocoele, Pseudo Myxoma
Peritonei, Perforation.

he had never encountered an instance of true congenital diverticulum formation in the appendix.

Aschoff² (1913) believed that diverticula resulted from an acute appen-



ditis causing scar tissue healing and that subsequent distension of the appendiceal lumen leads to mucosal herniations. Sturm³⁴ (1915) reported two further examples of congenital appendiceal diverticula occurring in stillbirths weighing 1,700 and 1,530 Gm. Grynfeldt and Chauvin¹² (1920) re-



ported an isolated case of inflammatory diverticula. Wilkie⁴⁰ (1921) described two cases of carcinoma of the appendix with accompanying diverticula extending into the meso-appendix. In one instance the carcinoma obstructed the lumen at the base of the appendix. Five congenital diverticula were

present which he believed were formed by the lumen occlusion allowing a secondary increase in the intraluminal pressure to occur. Löhr¹⁸ (1922) subscribed to the inflammatory origin of most appendiceal diverticula. Stout³³ (1923) experimentally injected saline into the submucosa and caused violent contractions of the muscularis to occur with a secondary protrusion of the mucosa and submucosa through the vascular hiatus in the muscularis. Bachlechner³ (1924) reported an example of a large twisted congenital appendiceal diverticulum occurring at the base in a male, age 17 years. This presented evidence of acute appendicitis. Malone²⁰ (1924) added an additional example of the congenital type, in which symptoms referable to the appendix had been present for the past six years. Ries²⁸ (1924) stated that appendices from which pseudomyxoma peritonei may originate are more or less cystic, often show diverticula formation and may contain papillomatous tumors. Such cases in females require careful investigation of the appendix. Chase⁵ (1927) believes with Aschoff² (1913) that the rapid loss of weight in a patient, allowing loss of adipose and fibrous tissues about a vascular hiatus in the muscularis, could cause a definite weakness in that region which may later be the site of diverticulum formation.

Pack and Scharnagel²⁷ (1928) believed that appendiceal diverticula exposed the individual to an increased liability to subsequent acute appendicitis, increasing the possibilities of perforation, and that they were often overlooked because they were situated in between the leaves of the meso-appendix. Most instances were of the false inflammatory type. Their material showed an incidence of 0.74 per cent of appendiceal diverticula formation. Masson and Hamrick²¹ (1930) described two cases of pseudomyxoma peritonei which originated from perforated appendiceal diverticula. Edwards⁸ (1934) found in his material that the average age of the patients was 42 years. All his instances had multiple diverticula and their most favored site of occurrence was along the meso-appendiceal border corresponding to the site of entrance of vessels. In contradistinction to diverticula formation elsewhere in the gastro-intestinal tract which exclusively elect the vascular hiatus through the muscularis, those of the appendix may occur in any situation around the appendiceal circumference.

Table I briefly summarizes the incidence of this pathologic entity as reported in the literature. Table II presents data derived from 60 of the cases included in Table I. The material which forms the basis of this study was derived from 30 cases which I have observed during the past ten years.

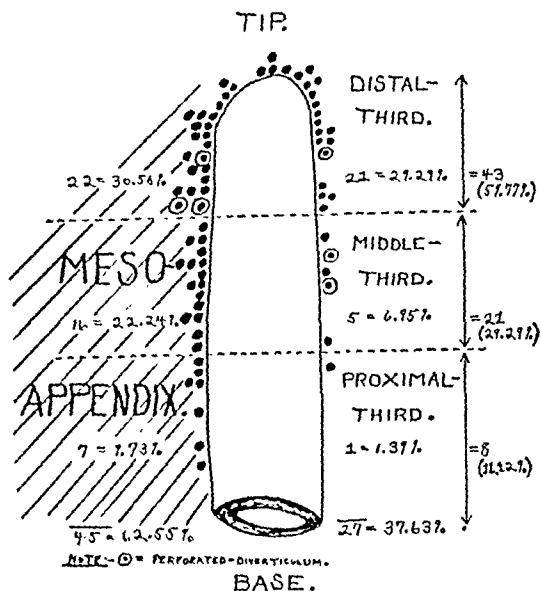


PLATE 6.—Diagrammatic representation of location of each individual diverticulum in this series.

Twenty-three of these occurred in 3,017 consecutive appendectomies (0.77 per cent), and the remaining seven examples were derived from 1,054 consecutive unselected postmortem appendices (0.66 per cent). Table III tabulates the important findings in this study, so that a comparison can be easily made with cases previously reported. Plates 1 to 6 graphically describe the individual cases that comprise this study. They are self-explanatory and do not need, therefore, to be reported in detail.

TABLE I

RÉSUMÉ OF INCIDENCE OF APPENDICEAL DIVERTICULA AS REPORTED IN THE LITERATURE

Author	Year	Source of Material	No. of Cases Studied	No. of Diverticula Found	Incidence Per Cent
Mertens.....	1902	Surgical	106	3	2.80
Beer.....	1904	Postmortem	106	2	1.99
Beer.....	1904	Surgical	28	1	3.56
Konjetzny.....	1909	Postmortem	1,000	2	0.20
MacCarty and McGrath.....	1911	Surgical	5,000	17	0.34
Moschowitz.....	1916	Surgical	1,500	4	0.27
Stout.....	1923	Surgical	264	5	1.89
Chase.....	1927	Surgical	394	3	0.76
Sauer.....	1930	Surgical	5,283	9	0.17
Mulsow.....	1932	Surgical	870	13	1.49
Edwards.....	1934	Surgical	1,493	8	0.53
Totals.....			16,044	67	Av. Incid. 0.42

TABLE II

DATA CONCERNING 60 APPENDICEAL DIVERTICULA REPORTED IN THE LITERATURE *

Sex: Females	48.3%
Males	51.7%
Age: Average age in 54 cases	35.7 yrs.
Average age for females	40.3 yrs.
Average age for males	31.1 yrs.

SITE OF LOCATION OF DIVERTICULUM

Tip.....	28.3%
Middle.....	55.0%
Tip and Middle.....	11.7%
Base.....	5.0%

NUMBER OF DIVERTICULA IN EACH SPECIMEN

One.....	59.9%
Two.....	18.3%
Three.....	5.0%
Four.....	8.4%
Five.....	5.0%
Six.....	1.7%
Seven.....	1.7%

DIVERTICULA OF THE APPENDIX

TABLE II. *Continued*

LOCATION OF BORDER WHERE DIVERTICULUM AROSE	
On meso-appendix border.....	63.3%
Partially from meso-appendix border.....	10.0%
On antimeso-appendix border.....	26.7%
PATHOLOGY ACCOMPANYING DIVERTICULA FORMATION	
Acute appendicitis.....	59.9%
Chronic appendicitis.....	33.4%
Perforation of the appendix.....	28.3%
Mucocele and pseudomyxoma peritonei.....	19.9%
"Carcinoma" of the appendix.....	8.4%
Congenital type of appendiceal diverticula.....	13.3%

* Above data derived from reports by: Seeling (1906), MacCarty and McGrath (1911), Wilkie (1921), Stout (1923), Ries (1924), Bachlechner (1924), Malone (1925), von Faykiss (1925), Chase (1927), Gardham, Choyce and Randall (1928), Arnold (1928), Sauer (1930), Stewart (1930), Masson and Hamrick (1930), and Mulsow (1932).

TABLE III

DATA CONCERNING 30 APPENDICEAL DIVERTICULA REPORTED IN THIS SERIES

Sex: Females	12	39.96%
Males	18	59.94%
SITE OF LOCATION OF DIVERTICULUM		
Tip and distal third.....		59.77%
Middle third.....		29.29%
Proximal third.....		11.12%
NUMBER OF DIVERTICULA IN EACH SPECIMEN		
One.....	9	29.97%
Two.....	13	43.29%
Three.....	3	9.99%
Four.....	1	3.33%
Five.....	1	3.33%
Six.....	2	6.66%
Seven.....	1	3.33%
LOCATION OF BORDER WHERE DIVERTICULUM AROSE		
On meso-appendix border.....	13	43.29%
Partially from meso-appendix border.....	7	23.31%
On antimeso-appendix border.....	10	33.30%
PATHOLOGY ACCOMPANYING DIVERTICULA FORMATION		
Chronic appendicitis.....	6	19.98%
Chronic obliterative appendicitis.....	6	19.98%
Subacute appendicitis.....	3	9.99%
Subacute appendicitis, carcinoid tumor at tip....	1	3.33%
Pseudomyxoma peritonei, mucocele, perforation .	3	9.99%
Early acute appendicitis.....	3	9.99%
Acute appendicitis.....	4	13.32%
Acute gangrenous appendicitis.....	2	6.66%
Acute perforative appendicitis.....	2	6.66%
Congenital true diverticula.....	2	6.66%

TABLE III. *Continued*

Length in Cm.	DIMENSIONS		AGE Years	SEX	
		Diameter in Mm.		Males	Females
4.0- 4.4	1	0.5	0	0	0
4.5- 4.9	0	0.6	0	0	0
5.0- 5.4	1	0.7	1	0	1
5.5- 5.9	0	0.8	3	0	0
6.0- 6.4	5	0.9	2	0	1
6.5- 6.9	2	1.0	3	0	4
7.0- 7.4	6	1.1	6	6	3
7.5- 7.9	3	1.2	4	35-39	2
8.0- 8.4	3	1.3	4	40-44	5
8.5- 8.9	3	1.4	1	45-49	2
9.0- 9.4	2	1.5	4	50-54	1
9.5- 9.9	1	1.6	1	55-59	0
10.0-10.4	2	1.7	0	60-64	1
10.5-10.9	0	1.8	0	65-69	1
11.0-11.4	1	1.9	0	70-74	0
11.5-11.9	0	2.0	1	75-79	0

LOCATION

A. Single Diverticula 9 29.97%

At tip.....	3	9.99%
Along meso-appendix border.....	4	13.32%
Along antimeso-appendix border.....	1	3.33%
Perforated into meso-appendix.....	1	3.33%

B. Multiple Diverticula 21 69.93%

1. Only on meso-appendix border.....	7	23.31%
Only on antimeso-appendix border.....	3	9.99%
On both borders.....	5	16.65%
At tip and meso-appendix border.....	2	6.66%
At tip and antimeso-appendix border.....	4	13.32%
2. Perforated cases.....	5	16.65%
a. Along meso-appendix border.....	3	9.99%
b. Along antimeso-appendix border.....	2	6.66%

Figs. 1 to 6 depict characteristic findings in four of the cases of this series.

Approximately 60 per cent of these cases were associated with acute inflammation and 16.6 per cent had perforated which in three instances initiated pseudomyxoma peritonei. Seventy per cent of the specimens possessed multiple diverticula, while 43.3 per cent were situated on the meso-appendiceal border. Sixty-two point five per cent of all of the diverticula had a similar location. Eighty per cent of these cases occurred in individuals past 30 years of age. The average dimensions of the appendices were 7.86 by 1.18 cm. The length is within normal limits, but the diameter is approximately 3.0 Mm. greater than normal. The 30 graphic drawings show the common presence of abnormal degrees of lumen stenosis and of greatly thickened appendiceal walls. Both of these findings are indicative of previous acute inflammations

DIVERTICULA OF THE APPENDIX

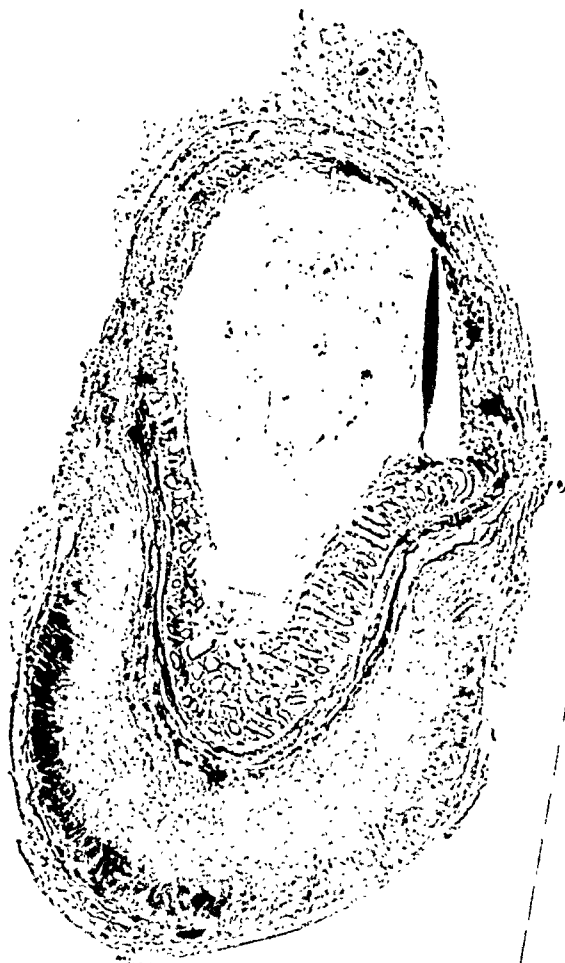


FIG. 1.—(Case 29.) Postmortem specimen. Base of the appendix. Inflammatory type of diverticulum. Note absence of muscularis in the walls of the diverticulum. It is this type which rapidly perforates in acute appendicitis. ($\times 14\frac{1}{2}$.)



FIG. 2.—(Case 22.) Surgical specimen. Proximal third of the appendix: cross-section of the lumen showing a beginning acquired diverticulum which is penetrating the muscularis through a vascular hiatus. Note the hypertrophy of the muscularis which is a common finding in this type of diverticulum. ($\times 6$.) Courtesy of Dr. Albert F. Brown.)

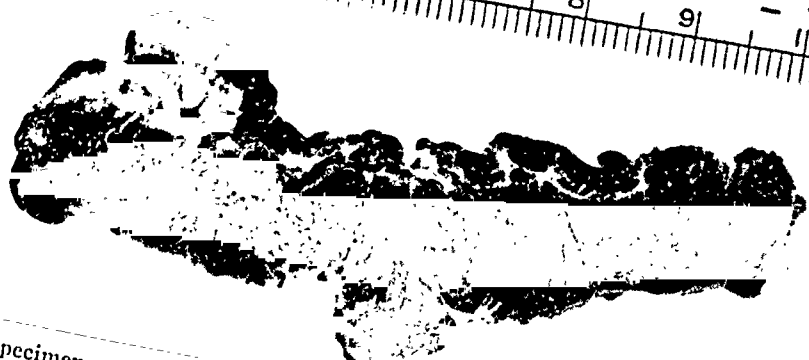
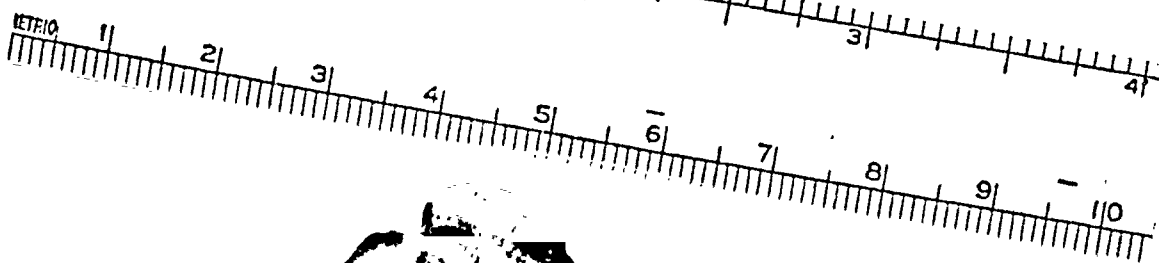
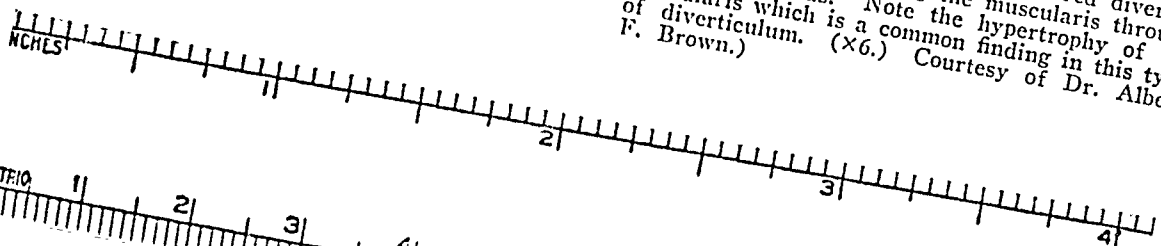


FIG. 3.—(Case 21.) Surgical specimen. Diverticula present at the tip and middle third of the appendix, on the antimeso-appendiceal border. Early acute appendicitis.

which were of considerable severity and produced marked narrowing or obliteration of the appendiceal lumen during the reparative processes of healing. This advanced degree of luminal narrowing was a most important causa-



FIG. 4.—(Case 21.) Surgical specimen. Cross-section through the large diverticulum in the middle of the appendix (Fig. 3). Typical acquired false inflammatory type of diverticulum showing acute, diffuse, ulcerative appendicitis. ($\times 6$.)



FIG. 5.—(Case 21.) Surgical specimen. Cross-section through the small diverticulum at the tip of the appendix (Fig. 3). Typical acquired false inflammatory type of diverticulum penetrating through the muscularis by a vascular hiatus. ($\times 6$.)



FIG. 6.—(Case 23.) Surgical specimen. Cross-sections of appendix showing two acquired diverticula associated with an early mucocoele, in the middle third. Section taken through the base of the appendix shows obliteration of the lumen. Subacute appendicitis. (Courtesy of Dr. H. A. Waggener.)

tive factor in this condition. Most of the specimens revealed marked hypertrophy of the muscularis. Cases 6 and 9 had congenital true diverticula.

CONCLUSIONS

Diverticula of the vermiform appendix are of importance inasmuch as subsequent acute inflammation in such appendices presents atypical signs and symptoms that are commonly followed by early perforation with the frequent causation of either generalized peritonitis or pseudomyxoma peritonei. Thus, it is imperative that during the course of abdominal explorations the appendix be examined under direct vision to rule out the presence of appendiceal diverticula. If diverticula are found, appendectomy should always be performed.

The literature upon this subject has been reviewed and the data derived from 60 previously reported cases have been tabulated. Thirty cases have been collected for study and their data have been summarized by means of tables and graphic drawings. A ready comparison is thus afforded between these two sources of material.

The incidence in this study was determined to be 0.77 per cent in 3,017 consecutive appendectomies and 0.66 per cent in 1,054 consecutive unselected postmortem appendices. Approximately 78 per cent of these cases were associated with varying degrees of acute inflammation at the time of their removal.

The great majority of instances were indirectly caused by a previous acute inflammation which in turn caused varying degrees of luminal atresia. The results and data obtained from this study are quite comparable with previously published studies.

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THE USE OF GLYCERYL TRINITRATE (NITROGLYCERIN) FOR THE CONTROL OF PAIN FOLLOWING CHOLECYSTECTOMY

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WE PREVIOUSLY have described an apparatus for measuring changes in pressure in the common bile duct.^{1, 2} Observations on intrabiliary pressure were made in cases in which T tubes had been placed in the common bile duct at the time of operation, for the purpose of prolonged biliary drainage. Recurrent attacks of biliary pain following cholecystectomy were found to be associated with an increased intrabiliary pressure as high as 160 Mm. of water, while in the same case this pressure ordinarily varied between 0 and 20 Mm. of water. Subcutaneous administration of 1/6 grain (0.01 Gm.) of morphine produced an increase in the intrabiliary pressure which began two to five minutes after administration and reached a peak of 200 to 300 Mm. of water ten minutes later.

An increase in pressure was accompanied in some cases by severe attacks of pain similar to those from which the patient ordinarily suffered. Inhalation of amyl nitrite was found to produce an immediate decrease in the intrabiliary pressure to zero, with relief of the pain, which, however, returned after ten minutes. When 1/100 grain (0.0006 Gm.) of glyceryl trinitrate (nitroglycerin) was placed under the tongue it produced a moderate decrease in the pressure and effected relief of the pain five minutes after administration. The effect lasted at least one hour.

This report is concerned with the case histories of individuals who suffered from the postcholecystectomy syndrome and with the results of the use of glyceryl trinitrate for the relief of the pain.

CASE REPORTS

Case 1.—A white male, age 32, had suffered from repeated attacks of severe epigastric pain since his gallbladder had been removed nine years before he came to the Clinic. At intervals of days, weeks, or months he had had attacks of excruciating epigastric pain which had extended to the back. During the course of the attacks, which sometimes had lasted as long as 18 hours, he occasionally had taken as much as 12 grains (0.77 Gm.) of sodium amytal, a pint of whisky, and even inhalations of chloroform.

Physical examination was negative. Roentgenologic examination of the stomach, kidneys, ureters, and bladder did not reveal any abnormality.

Subcutaneous administration of 1/6 grain (0.01 Gm.) of morphine sulphate was followed in 15 minutes by an attack of excruciating epigastric pain. Inhalation of amyl

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nitrite produced immediate and complete relief. Pain returned in ten minutes, at which time 1/100 grain (0.0006 Gm.) of glyceryl trinitrate was placed under his tongue. This produced complete relief of pain in five minutes. Pain returned in one hour; this undoubtedly was attributable to the continued action of the morphine. While the patient was under our observation, administration of glyceryl trinitrate again relieved the pain. This time the pain did not return.

Laparotomy revealed the common bile duct dilated to twice the normal size. The common bile duct was opened and a small scoop was passed into the duodenum. No stones were found but a definite tug was experienced as the scoop passed the sphincter of Oddi. There was some thickening of the head of the pancreas. A T tube was inserted into the common bile duct for prolonged drainage. The postoperative course was uneventful and the patient was dismissed but was instructed to return later for removal of the T tube.

Case 2.—A nurse, age 27, had undergone a cholecystectomy because of attacks of pain in the right upper quadrant of the abdomen, accompanied by nausea and vomiting, a year and one-half before she came under our observation. The gallbladder had been found to be the site of a chronic inflammation but it had not contained any stones. The patient had been well until four months following the cholecystectomy, when a tight feeling had developed around the lower part of the thorax and she complained of pain at the right subcostal margin. It had been associated with vomiting which had continued for four hours. The pain had not been relieved by codeine which had been administered hypodermically. Residual soreness had remained for two days. There had not been any elevation of temperature at the time of this attack. During the year previous to her coming under our observation, she had had other similar attacks, which had forced her to stop work and go to bed. Administration of glyceryl trinitrate has produced prompt relief of the last three attacks and has permitted the patient to continue her work.

Case 3.—A woman, age 38, had undergone a cholecystectomy five years before she registered at the Clinic. Following this operation she had continued to have repeated attacks of pain in the right upper quadrant of the abdomen; the pain had extended to the back and had been associated with fever, and at times with jaundice. She volunteered the information that she had never been able to get complete relief during the attacks and that two and even three hypodermic injections of morphine had been administered without effect. Exploratory laparotomy had been performed on four different occasions but she had not obtained any relief. At the time of the last exploration, the common bile duct had been opened but no stones had been found. Prolonged biliary drainage had not been instituted.

On arrival at the Clinic she was seized with a severe attack of pain, which began at the ninth costal cartilage and extended around the right side to the back. Complete relief was obtained by the administration of 1/100 grain (0.0006 Gm.) of glyceryl trinitrate. Laparotomy revealed the common bile duct dilated to four times its normal size, but it did not contain any stones. The head of the pancreas was essentially normal. There was an associated cholangitis and a hepatitis, Grade 3, on a basis of 4. A T tube was inserted into the common bile duct. The patient was comfortable following the operation. An injection of morphine produced the usual increase in intrabiliary pressure and a typical attack of biliary pain resulted.

Case 4.—A woman, age 48, was admitted to the Clinic May 12, 1936, because of jaundice, pruritus, and loss of weight. In 1929 she had begun to have repeated attacks of biliary colic with occasional jaundice. Her gallbladder had been removed in April, 1935. In October, 1935, indigestion, pruritus, and jaundice had returned and had continued until the present time. The value for the serum bilirubin was 19.36 mg. per 100 cc. The hippuric acid test revealed an excretion of 2.71 Gm. of hippuric acid and 1.83 Gm. of benzoic acid in the urine. While the patient was in hospital she was seized with pain in the right upper quadrant of the abdomen. This was relieved by

inhalation of amyl nitrite, after which the pain did not return. On May 19, 1936, a laparotomy disclosed a common bile duct enlarged to about 2.5 cm. in diameter. It contained a stone of equal diameter. There was some narrowing in the pancreatic portion of the duct, and some thickening of the head of the pancreas. The pancreatitis was considered to be Grade 3, on a basis of 4. The liver was brownish in color and showed hepatitis Grade 3+.

Case 5.—A woman, age 56, was admitted to the Clinic May 5, 1936, complaining of frequent attacks of vomiting. Twenty years previously she had suffered from attacks of biliary colic. Her gallbladder had been drained and 12 stones had been removed. Four years before she came under our observation her gallbladder had been removed. It contained a stone and one was also found in the common bile duct. Following this operation she had continued to have repeated attacks of pain in the right upper quadrant of the abdomen. During the past year these attacks had been replaced by a dull ache. Vomiting had been present for the past four years, but had become more severe during the last year. She had vomited bile stained fluid about half an hour after a meal. The results of physical examination were essentially negative. She had never been jaundiced. On May 11, 1936, she was given morphine, grain $1/6$ (0.01 Gm.), as part of the preoperative medication. This was followed shortly by severe pain in the right upper abdominal quadrant. Inhalation of amyl nitrite gave prompt and complete relief. At operation the common bile duct was found to be about twice the normal size; it was opened and two black lozenge-shaped stones, each about 1.2 cm. in diameter, were removed. Following this it was possible to slip first a small scoop, then a large one, through the ampulla of Vater and into the duodenum. Her convalescence has been satisfactory.

Case 6.—A woman, age 37, registered at the Clinic June 1, 1935, because of persistent biliary and duodenal fistulae. In 1913 she had undergone a cholecystostomy for gallstones. In 1923, she began to have recurrent attacks of biliary colic every two to three months. The colic had been accompanied by chills, fever, vomiting, and sometimes by slight jaundice. Pain had extended around into the right scapular region. Two to three hypodermic injections of morphine had usually been necessary to secure relief. In January, 1935, cholecystectomy had been performed elsewhere and the gallbladder had been full of stones. The common bile duct had not been explored. On the tenth postoperative day food and bile had drained through the incision.

She was operated upon at the Clinic June 7, 1935. A duodenal fistula near the pyloric sphincter was closed and a pyloroplasty was performed. The common bile duct was slightly enlarged. It was explored but no stones were found. She made an uneventful convalescence. She returned on March 18, 1936, because she had had ten severe and many mild attacks of epigastric pain. These had occurred between 7 and 9 P.M. and lasted until $1/2$ to $3/4$ of a grain (0.032 to 0.05 Gm.) of morphine was administered. Pain extended to the right shoulder. The pain had been exactly similar to that which had occurred before the removal of her gallbladder. The severe attacks had been followed by residual soreness, itching and jaundice; the stools had been of a light color for one or two weeks after the attack. There had not been any qualitative food distress.

On March 24, 1936, operation showed the gastroduodenostomy to be in excellent condition. Some narrowing of the common bile duct was noted in the region of the hepatic ducts. This was dilated. A T tube was inserted into the common duct and sutured. She made an uneventful convalescence. On the twenty-first postoperative day the intrabiliary pressure was 78 Mm. of water, much higher than the average pressure, which varies from 0 to 20 Mm. of water. Morphine, $1/6$ grain (0.01 Gm.), was given subcutaneously. In two and one-half minutes the patient complained of a feeling of pressure in the right upper quadrant of the abdomen. She said that she felt like she did when an attack was about to begin. Eight minutes after administration of the morphine, she complained of severe pain in the right upper quadrant of the abdomen.

She felt "hot" all over and was nauseated, remarking that all of these symptoms had accompanied the regular attacks of pain. The intrabiliary pressure at this time was 140 Mm. of water. The T tube was disconnected from the apparatus in order to allow the bile to flow out freely. At the same time inhalation of amyl nitrite was given. These measures gave relief except for some residual soreness. On the following day choledochograms were taken in order to determine the cause of the persistent intrabiliary pressure. The roentgenogram revealed a spasm at the lower end of the common bile duct, at the level of the second lumbar vertebra (Fig. 1a). A second choledochogram, which was taken after 1/100 grain (0.0006 Gm.) of glyceryl trinitrate had been

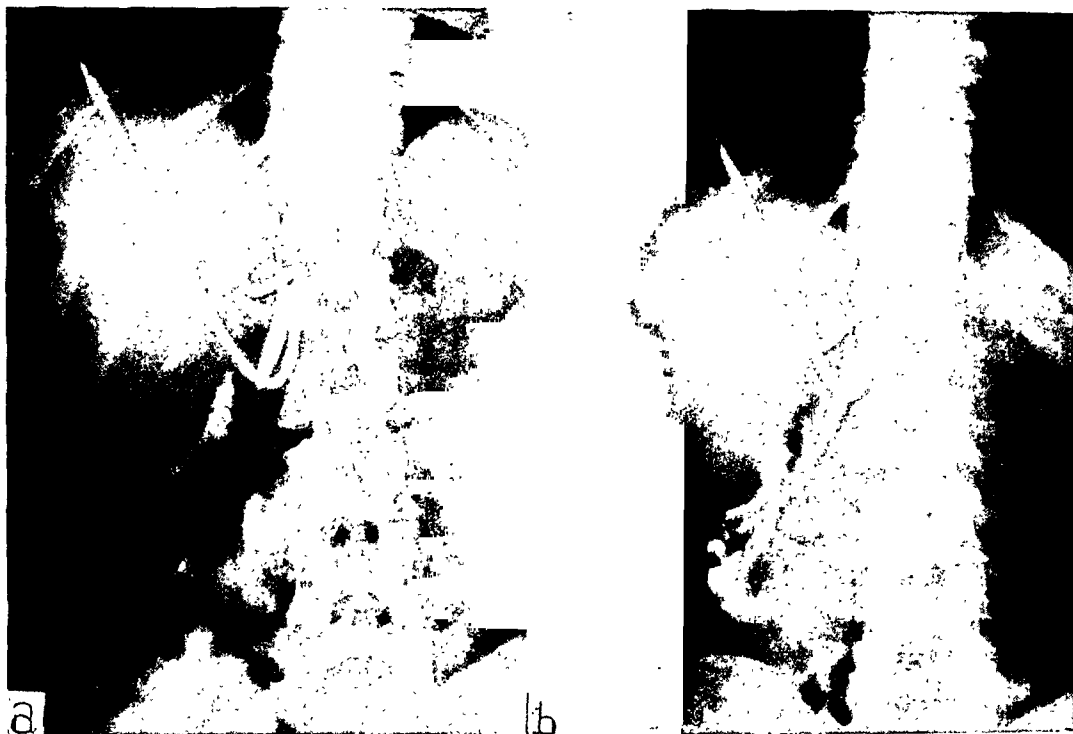


FIG. 1.—(a) Roentgenogram made following injection of brominol, showing obstruction at the lower end of the common bile duct at the level of the second lumbar vertebra. This patient had a persistent increase in pressure within the common bile duct to 70 Mm. of water (normal 0 to 20 Mm.) (b) Roentgenogram of same patient as shown in (a) and made with the same technic five minutes after administration of amyl nitrite. There is no evidence of spasm at its original site although there is some narrowing of the common bile duct below this point.

placed under the patient's tongue, revealed complete absence of any suggestion of a spasm, although it did reveal a very definite narrowing of the lower end of the common bile duct, opposite the third lumbar vertebra (Fig. 1b).

ADDITIONAL CASES

We will briefly mention six other cases in which the patients had attacks of biliary colic following removal of the gallbladder. In one case the patient was a woman; an attack of biliary colic was induced by the injection of 1/6 grain (0.01 Gm.) of morphine sulphate, given as part of the preoperative medication before a partial thyroidectomy. Inhalation of amyl nitrite effected relief for 15 minutes. In another case, a physician, an attack of biliary colic developed following the injection of 1/6 grain (0.01 Gm.) of morphine in connection with the extraction of a tooth. The attacks of pain from which this patient ordinarily suffered were severe enough to require 1/2 grain (0.032

Gm.) of morphine and incapacitated him for a day. On two occasions he had been able to relieve an attack of pain by taking glyceryl trinitrate. In a third case the patient was a woman who had her breast amputated at the Clinic. One grain (0.065 Gm.) of codeine, which was administered subcutaneously, produced an attack of biliary colic which lasted for several hours. The patient said that "hypodermics" previously had produced attacks of pain.

In three other instances pain occurred in the right upper quadrant of the abdomen during convalescence following cholecystectomy. In each the pain was promptly and completely relieved by administration of glyceryl trinitrate.

ADMINISTRATION OF GLYCERYL TRINITRATE TO RELIEVE BILIARY COLIC

We have observed relief of biliary colic by means of administration of glyceryl trinitrate in two cases in which the gallbladder was present at the time the drug was given. In one of these cases the patient was a woman, age 22, who complained of repeated attacks of pain in the right upper quadrant of the abdomen, which had occurred intermittently for two years. The roentgenogram revealed a gallbladder full of stones. We had the opportunity of observing her during an attack which continued for one and one-half hours in spite of the administration of two doses of morphine, each of which consisted of 1/6 grain (0.01 Gm.). Forty-five minutes after administration of the second dose of morphine, inhalation of amyl nitrite produced immediate relief of pain. It returned ten minutes later, at which time 1/100 grain (0.0006 Gm.) of glyceryl trinitrate, placed under the tongue, produced complete relief in two and one-half minutes. Pain returned in one hour, undoubtedly as the result of the continued action of morphine. A second dose of glyceryl trinitrate produced complete and permanent relief. She was later operated upon and a gallbladder full of stones was removed. The common bile duct was normal in size and color, and no stones could be felt in it, so it was not opened.

In the other case, a man, age 66, had suffered from repeated attacks of biliary colic, accompanied by gaseous eructations, nausea, and light colored stools. Because of the presence of bronchial asthma and a definite pulmonary emphysema, an operation was considered inadvisable. Glyceryl trinitrate was prescribed for the relief of the pain. He reported prompt and complete relief. In this instance the possibility of angina pectoris must be considered, although the history was typical of biliary colic.

COMMENT.—The data which we have collected on the subject suggests that administration of morphine is likely to precipitate an attack of biliary colic. Administration of 1/6 grain (0.01 Gm.) of morphine in such cases will frequently produce an increase of intrabiliary pressure to 160 to 300 Mm. of water for two or more hours, accompanied by severe pain. While a large dose of morphine will decrease the patient's sensibility to pain by acting on the higher nerve centers, it, at the same time, prolongs and even augments the increase in pressure in the common bile duct. Patients who have disease of the gallbladder frequently say that morphine gives them a feeling of fulness

or makes them sick. The explanation probably is that a normally functioning gallbladder can maintain intrabiliary pressure at a normal level by absorption of fluids and relaxation of its smooth muscle, while a diseased gallbladder, on the other hand, does not possess this function. We suggest the use of morphine as a diagnostic procedure in the study of patients who have the post-cholecystectomy syndrome. If administration of morphine brings on an attack of pain and glyceryl trinitrate relieves it, the evidence is in favor of the condition being the result of a disturbance in the sphincteric mechanism at the lower end of the common bile duct either with or without associated stones in the common bile duct. Administration of glyceryl trinitrate, in doses of 1/100 grain (0.0006 Gm.), will relieve the pain associated with the post-cholecystectomy syndrome. We do not recommend its use, except as a temporary measure until after the common bile duct has been explored, since stones in the common duct may account for the sphincteric spasm.

We have not seen any untoward effects from the use of glyceryl trinitrate, except a feeling of warmth, weakness, and occasionally a tightness in the head. These are very transitory, however, and pass off in a few minutes. However, we recommend that the patient be in the recumbent position when the drug is taken. We have found that the tablets made for hypodermic use are more effective than the regular triturations.

SUMMARY

We have reported a series of nine cases in which repeated attacks of biliary colic developed after the gallbladder had been removed. In these cases, subcutaneous injection of 1/6 grain (0.01 Gm.) of morphine sulphate produced pain, which was completely relieved by administration, under the tongue, of 1/100 grain (0.0006 Gm.) of glyceryl trinitrate, or by inhalation of amyl nitrite. In two of these cases stones were subsequently found in the common bile duct at operation.

We have mentioned two cases in which pain, which was associated with biliary colic and which occurred before cholecystectomy, was relieved by administration of glyceryl trinitrate. In three other cases the patients were relieved of similar attacks which occurred shortly after cholecystectomy.

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AN OPERATIVE PROCEDURE FOR RIGHT-SIDED ULCERATIVE ILEOCOLITIS

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ULCERATIVE colitis frequently commences in the ascending (right-sided colitis) or in the transverse colon. When it originates in the right side of the colon, it extends backward to the caput coli and through the ileocecal valve into the ileum, and also forward into the transverse, descending and sigmoid colon. When the disease commences in the transverse colon, it likewise extends in both directions, *i.e.*, backward towards the cecum and into the ileum, and forward into the descending colon and sigmoid. When the ileum becomes involved, we have termed the condition ulcerative colo-ileitis to indicate that the disease originates in the colon and extends subsequently into the ileum. The sigmoid flexure and rectum in these cases of right-sided and transverse colitis are involved only in the very late stages of the disease. Sigmoidoscopy will usually show the sigmoid and rectum to be uninvolved. This is confirmed by roentgenologic examination which shows the sigmoid to be ballooned out to retain its normal haustrations.

In the severe cases of right-sided and transverse colitis, those that have resisted all forms and types of medical treatment, it has been the practice of some surgeons to establish an ileostomy in order to exclude the entire colon from the fecal stream and thus put the colon at rest; others perform an ileosigmoidostomy with the same object in view, but ileosigmoidostomy surely does not put the colon at rest or divert the feces from the diseased colon because retrograde peristalsis carries the upper portions of the colon into the ileum into the upper portions of the colon. Besides, it has the additional disadvantage of delivering fecal material onto the abdominal wall and thus is an additional serious source of infection if further operative procedure upon the diseased colon is to be carried out.

In order to put the diseased colon completely at rest and in order to irrigate and cleanse it thoroughly, I have, in five cases, carried out the following procedure: A left-sided transrectus incision is made extending three or four inches upward from the symphysis; the terminal ileum is identified and delivered out of the wound. The healthy sigmoid is similarly recognized and delivered into the abdominal wound. The healthy ileum, as near to the ileocecal valve as is possible, is cut completely across and its mesentery divided. Both ends are closed by two or three tiers of sutures (Fig. 1), an inner chromic catgut through all the coats, reinforced by one or two layers of interrupted linen or chromic catgut sutures. The proximal end of the ileum

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is now joined to the lower sigmoid just above the peritoneal reflection by a side-to-side anastomosis. Several inches above this side-to-side anastomosis the sigmoid is cut completely across, the distal end closed by a row of chromic catgut sutures reinforced by one or two layers of linen or catgut, and the

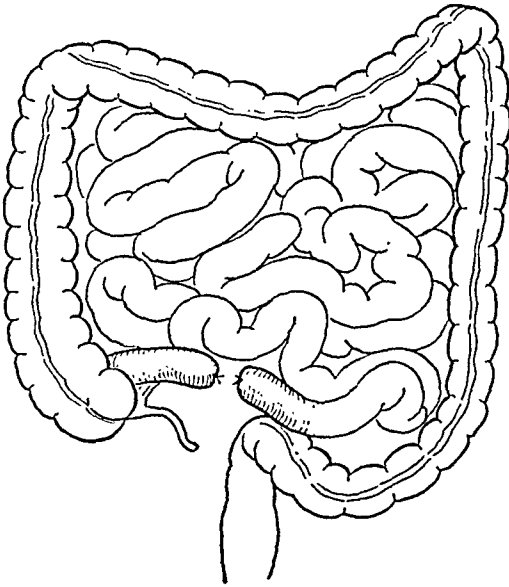


FIG. 1.—Division and closure of both ends of the terminal ileum above the site of disease.

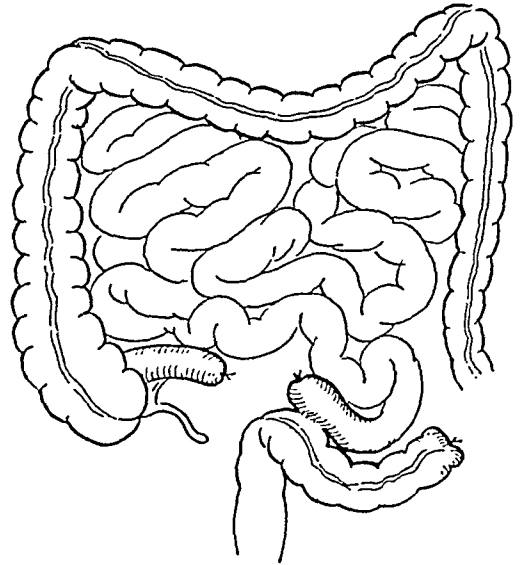


FIG. 2.—Implantation of proximal end of ileum into the lower sigmoid. Complete division of two upper ends of sigmoid. Closure of the distal end of sigmoid. Establishment of artificial anus in proximal end of sigmoid.

proximal end tied off with a heavy silk suture, thoroughly carbolyzed and brought out through the upper angle of the wound (Fig. 2). The rest of the abdominal wound is closed in layers.

The heavy silk suture around the proximal end of the sigmoid is left in situ for 48 to 72 hours and then removed, leaving a fistula in the proximal end of the sigmoid (Fig. 3). The fecal stream is thus entirely diverted into the lowermost sigmoid and rectum, and the fistula in the sigmoid permits the free drainage of the products of inflammation from the diseased colon. After 10 to 14 days, the colon is irrigated through the sigmoidal fistula.

In two cases the entire colon and the diseased portion of the ileum have been subsequently removed.

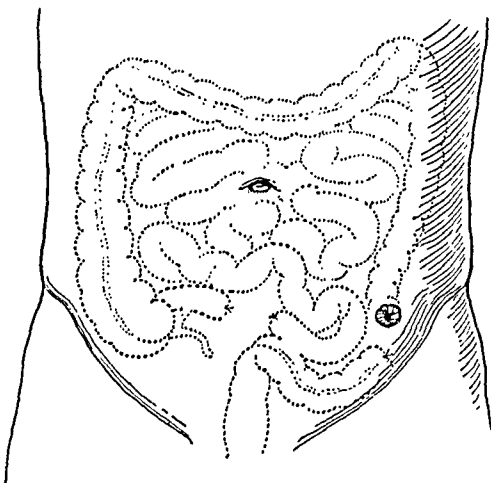


FIG. 3.—Artificial anus of proximal end of sigmoid.

CASE REPORTS

Case 1.—Male, age 20, referred by Doctor Crohn. He had an ulcerative colitis which commenced in the proximal portion of the transverse colon. While under observation and treatment, the disease had extended backward into the caput coli and through the ileocecal valve into the ileum. It had also extended forward through the whole of

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the transverse colon and up into the upper third of the descending colon where it had stopped abruptly. The lower half of the descending colon and sigmoid were entirely normal.

At the time of examination, he was very sick. The disease had resisted all forms of treatment. He was having temperatures between 102° and 104° F.; had a profuse bloody, purulent diarrhea and had lost a great deal of weight. After repeated transfusions, the above described operative procedure was carried out.

Within 48 hours after the operation, the temperature became normal and his general condition began to improve. He was discharged from the hospital after three

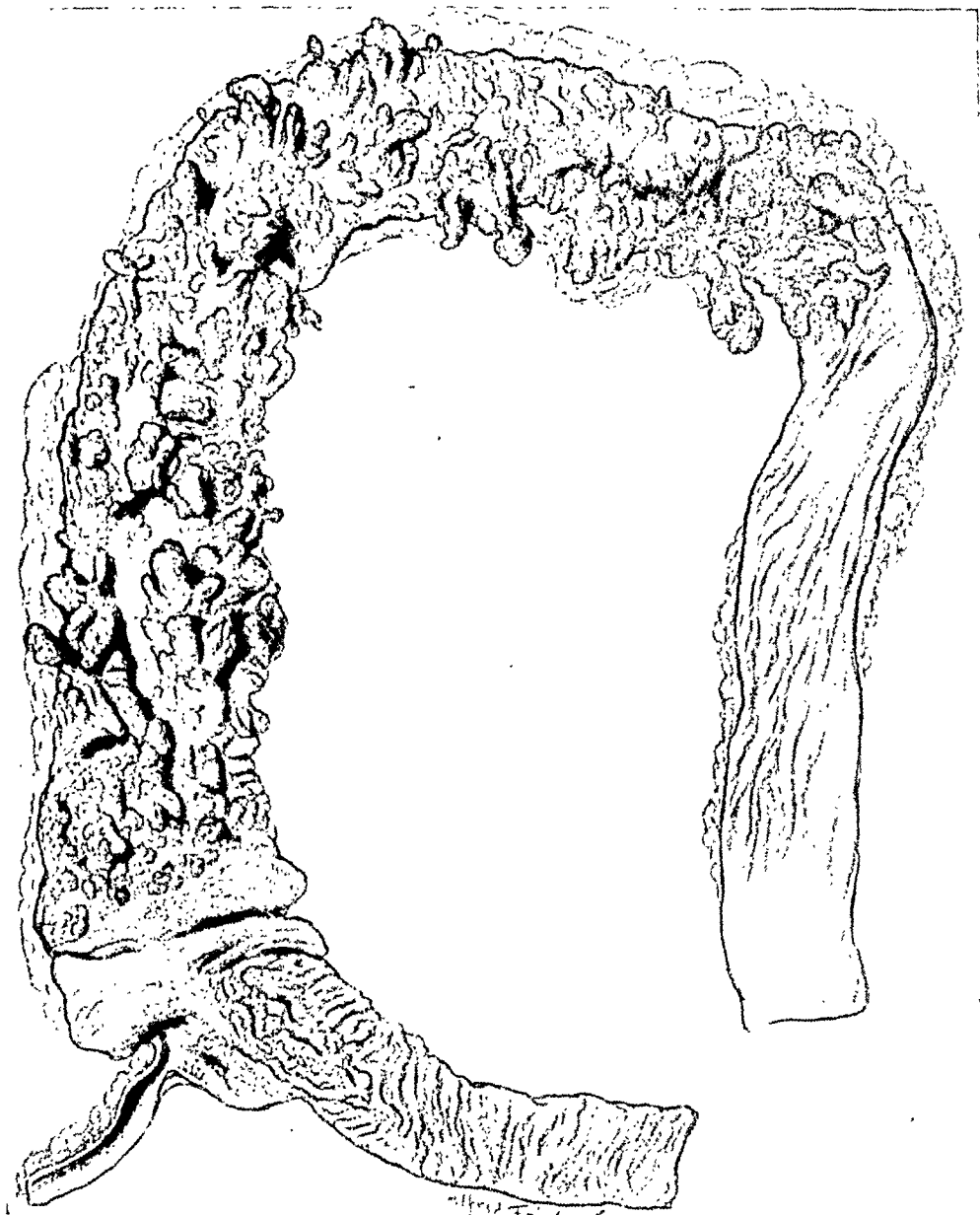


FIG. 4.—Ulcerative colitis involving the ascending and transverse colon and extending into the terminal ileum.

weeks, with normal temperature, discharging considerable pus and blood through the sigmoidal fistula, and having but three or four normal fluid stools daily.

Four months after this first operation, the diseased terminal ileum, the whole ascending, transverse, descending colon and sigmoid down to and including the fistula were removed at one operation. He made an uninterrupted convalescence and was discharged four weeks after operation. He is gaining rapidly in weight, has usually three normal semisolid movements a day; appetite is good. His blood examination was practically normal (Fig. 4).

Case 2.—A young lady came under observation 14 years ago, suffering from a very severe ulcerative colitis which involved the caput coli and the ascending colon. For several years after the onset of her disease, there were periods during which she was very ill with high temperature and profuse, bloody, purulent diarrhea. During one of these exacerbations, an appendicostomy was performed by Dr. Joseph Blake, with the idea of irrigating the diseased colon.

This operation gave her no relief. She continued to have severe, bloody, purulent diarrhea and at times severe recrudescences of fever lasting for many weeks. About four years after the establishment of this appendicocostomy, the patient demanded that

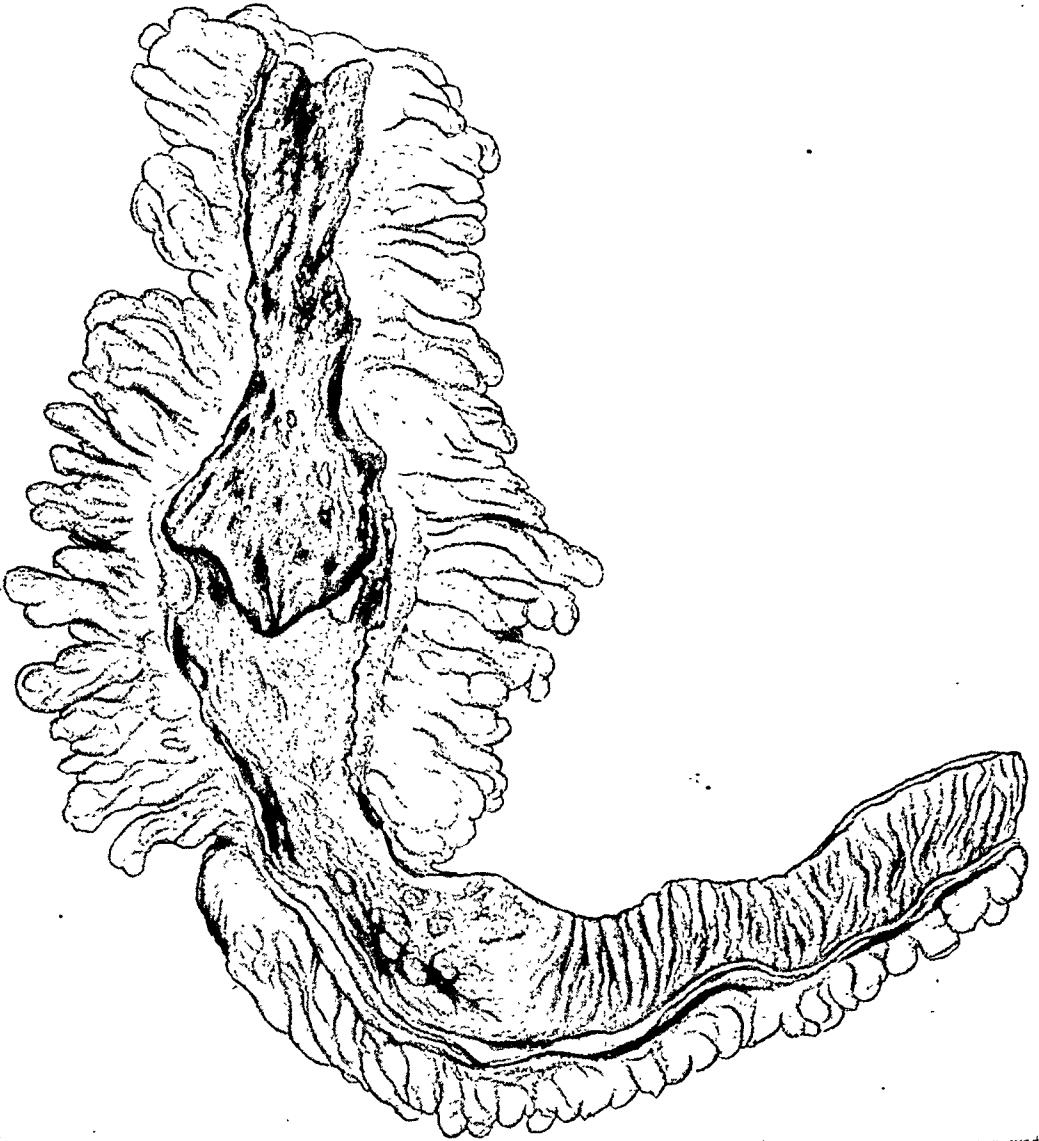


FIG. 5.—Ulcerative colitis involving sigmoid and colon and extending into the terminal ileum.

the artificial opening be closed, it having become a source of great annoyance, constantly giving rise to infections of the abdominal wall around the site of the fistula and apparently affording no benefit.

Upon opening the abdomen with the intention of closing the fistula, the caput coli was found thickened and indurated and had lost all of its elasticity. The terminal ileum was healthy. The fistulous opening in the cecum was closed by a plastic procedure. This remained closed for two months when the suture line broke down and the fistula was reestablished.

For the next three years the course of the disease was about the same. The recrudescences of high temperature and the continuous bloody, purulent diarrhea persisted. A second attempt was made to close the fistula, at which operation the terminal ileum was found to be normal; the caput coli, however, had become even more rigid and leathery. By removing the mucosa and the submucosa of the wall of the cecum adjacent to the fistula, enough soft and elastic cecal wall was secured to effect closure of the opening. A satisfactory result was obtained for a period of three months when the suture line again broke down, resulting in the reformation of the fistula.

The disease again continued in its severe course with intermissions of comparative well being, but the severe, bloody, purulent diarrhea continued. At times, the large joints became swollen and were markedly inflamed and attacks of iritis seriously threatened her eyesight.

In November, 1935, the patient was in poor condition and the question of radical removal of the diseased colon was considered. Sigmoidoscopy showed the rectum and lowermost sigmoid comparatively uninvolved. There were some small superficial ulcerations of the mucous membrane in the lower sigmoid but no polyposis. Roentgenologic examination demonstrated the rectum and lowermost sigmoid to be elastic and ballooned out.

The procedure previously detailed was carried out, *i.e.*, ileosigmoidostomy just above the peritoneal reflection, closure of the distal end of the ileum, division of the sigmoid, closure of the distal end of the sigmoid and establishment of a sigmoidal colostomy. Her course after this operation was encouraging. Her stools became free of blood and pus, there being about four to five fluid semisolid movements a day. Through the sigmoidal colostomy, however, as much as eight to 15 ounces of purulent, bloody material were discharged every 24 hours. Her general condition improved and her temperature remained normal. All joint and eye lesions disappeared.

After four months the terminal ileum, which had become very much diseased, was removed as well as the ascending and proximal half of the transverse colon (Fig. 5). Her general condition contraindicated the complete removal of the colon. At the present time her general condition is very much improved. She has about three to four semisolid movements a day, normal in character. The fistula in the sigmoid discharges about five drops of purulent material in 24 hours. The remaining portion of the colon will be removed subsequently.

The other three cases operated upon according to this method have not had the colon removed as yet. One is that of a boy desperately ill and delirious with high temperature, who improved immediately after operation. Another one, a case of polypoid colitis, is awaiting colectomy. The third one has improved so much and has so little discharge from the diseased colon through the sigmoidal colostomy, that she is debating the necessity of having the diseased colon removed.

CONCLUSIONS

By this procedure, one is enabled, first of all, to put the diseased colon completely at rest.

An outlet is afforded for the blood, pus and other products of inflammatory reaction.

Cleansing of the diseased colon by irrigating fluids can be readily carried out.

Where a colectomy is contemplated, its dangers are not increased by the presence of a discharging ileostomy wound.

The procedure is not attended with much shock, and as seen in our cases, can be tolerated even during the severe exacerbations of the disease.

THE SURGICAL TREATMENT OF FIVE HUNDRED HERNIAE

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THE surgical treatment of hernia has now progressed to the extent that in the absence of complications such as strangulation, it is attended by practically no mortality. The results have become increasingly satisfactory. Occasional recurrences, however, are encountered, and this, together with the fact that herniae of various types constitute the second most frequent lesion encountered on a general surgical service, makes careful analyses of groups of cases worthwhile in evaluating the procedure employed and perhaps in indicating where other methods would have been preferable. An analysis of 500 consecutive cases is therefore presented, including 367 inguinal, 34 umbilical, 33 femoral, 18 epigastric, and 48 postoperative ventral herniae. Each type was treated by the same or similar operative procedure, and the technic in all types included the use of silk as a suture material.

Many factors may, of course, influence the adequacy of the repair of a hernia, but not the least of these is the condition of the structures which must be utilized in the repair. Their condition may in turn depend upon a number of circumstances such as the muscular development, the age of the patient and his general state of health. Of all of these, however, the most important single factor is the duration of the hernia, and for this reason operation should be undertaken as soon as possible after the hernia is recognized.

An effort has been made to reduce the incidence of infections and post-operative pulmonary complications which contribute to the poor results and the mortality in hernial operations by the adherence to detail of procedure. There were no deaths in this series of cases, few infections and no serious pulmonary complications.

General Technic.—The preoperative treatment of hernia is not distinctive save in obese patients in whom respiration and circulation may be embarrassed by the return of hernial contents to the abdominal cavity. Such a case is prepared for operation by spending from two to seven days in bed with a tight binder applied to the abdomen. Catharsis is freely administered and a liquid diet is given for the purpose of decompressing the intestinal tract. An extremely obese patient is advised to reduce before surgical treatment is undertaken, unless postponement is contraindicated.

Anesthesia.—We prefer local anesthesia in hernia operations, mainly for two reasons: (a) postoperative pulmonary complications appear to be less frequent; (b) nausea and retching, which place an extra strain upon the wound, are less severe. The opinion held by some that the injection of a local anesthetic leads to infection is not borne out by our experience in this series of cases, as there were no deep infections.

The details of the operative procedure will be discussed under the several headings. In all hernia cases the field is prepared with care to avoid contamination from unprepared areas. The dissection is carried out with a sharp instrument, bleeding vessels are ligated with meticulous care, using silk ligatures. The wound is repaired with interrupted silk sutures, except when infection is present.

Postoperative Care.—All patients operated upon for hernia are kept in bed for 14 days unless the hernia has been large or the structures of less than usual strength, when the period in bed may be prolonged.

Inguinal Hernia.—In the group of 367 inguinal herniae there were 303 indirect, 38 direct, and 26 recurrent herniae. Three hundred and six operations were performed under local, 45 under general and 16 under spinal anesthesia.

Indirect Inguinal Hernia.—In repairing an indirect inguinal hernia, we use one of two methods. If the structures are strong and the defect small, a Halsted¹ repair without transplantation of the cord is done. In this procedure, the sac is dissected up to its neck, where it is ligated and transfixed with doubled silk. The stump retracts behind the internal oblique muscle. The cremaster muscle and fascia are drawn up under the edge of the conjoined tendon and internal oblique muscle in an effort to partially obliterate the inguinal canal. The edges of the internal oblique muscle and conjoined tendon are sutured to Poupart's ligament, the cord being closely embraced by these structures as it emerges. The margin of the lateral portion of the external oblique is then secured beneath the mesial portion by a series of mattress sutures and the mesial portion of the external oblique is brought to overlap this laterally and secured in a similar manner. The sutures throughout this procedure are interrupted and of black silk.

If the structures are weak or if the defect is large, a Halsted repair with transplantation of the cord to the subcutaneous tissue is done. This is the procedure with which the term Halsted hernial repair is most commonly associated. All the muscular and fascial layers are united beneath the cord. This obliterates completely the old external ring and makes a new one, which, although opposite the internal ring, tends to permit recurrences less frequently.

Two points concerning technic are emphasized: (a) sutures should not be drawn so tightly as to interfere with the circulation in the tissue and thus weaken the repair; (b) approximation of the structures should be accomplished without undue tension after adequate mobilization so as to permit the newly constructed abdominal wall to heal without separation.

Seventeen of the 303 indirect inguinal herniae required immediate operation because of incarceration or strangulation. Two hundred and fifty-three of these patients have been studied in the Follow Up Clinic and of these, six have not been cured by operation, an incidence of recurrence of 2.37 per cent.

Direct Inguinal Hernia.—Indirect inguinal herniae, for the most part, develop because of a congenital weakness brought about by the descent of the testicle into the scrotum, whereas the direct herniae occur because of an

acquired attenuation of the structures comprising the conjoined tendon. In these latter, therefore, to overcome the weakness of the abdominal wall, a repair with transplantation of the cord is more frequently necessary.

Thirty-two of the 38 patients have been studied in the Follow Up Clinic and of these two showed evidence of recurrence, an incidence of 6.21 per cent.

Recurrent Inguinal Hernia.—The 26 patients in this group had been operated upon elsewhere, from one to four times, previous to their admission to this clinic. The usual technic we employed was that of Halsted with transplantation of the cord to the subcutaneous tissues. All recurrences occurred in direct herniae in five of which the cord was transplanted and one in which transplantation was omitted in the repair. Twenty of the 26 patients have been observed in the Follow Up Clinic, of which six cases or 30 per cent had recurrences.

It has been suggested by Gallie² that large fascial transplants be used to fill the defect where structures cannot be readily approximated. In his series of cases there were recurrences in only 10 per cent. His method will be tried here in the future in the hope that the incidence of recurrences may be lowered.

Femoral Hernia.—In the group of 33 femoral herniae there were 19 on the right side. This predominance on the right has been observed by others. Thirty of these patients were female, three were male. Ten cases required immediate operation; five for incarceration and five for strangulation. The procedure was carried out through an inguinal incision and the sac exposed below Poupart's ligament. The external oblique fascia and the peritoneum were then divided, and the hernia and its contents reduced. The neck of the sac was inverted and closed. The femoral ring was then obliterated in the classic manner, employing silk sutures to approximate the pectineus fascia and Poupart's ligament.

Twenty-six of the cases in this group were studied in the Follow Up Clinic. There were three recurrences, an incidence of 11.1 per cent. One case had been operated upon in the fourth month of pregnancy and recurred soon after delivery, while another had worn a truss for 16 years prior to operation. In the third there was no evident cause for recurrence.

The fact that femoral hernia occurs more frequently in later life is borne out by this series, in which 27 of the 33 patients were over 40 years of age. The incidence of incarceration and strangulation was higher in this type than any other. Ten or 30 per cent of these were acute herniae. The age incidence and the frequency of intestinal obstruction in this group explains the higher mortality generally associated with it. For example, it was necessary to operate for a strangulated femoral hernia in a woman over 80 years of age who had had intestinal obstruction for almost 48 hours.

Umbilical Hernia.—Twenty of the 34 cases in this group were markedly obese. The hernia had persisted for long periods of time in the majority of instances but was not associated with serious symptoms. The size of the hernial ring was moderate except in the three recurrent umbilical herniae in which it was very large. Nine cases were acute, five requiring immediate

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operation for incarceration and four for strangulation. The majority of these herniae were repaired by the method advocated by Blake,³ which consists of the longitudinal overlapping of fascia of the recti utilizing the anterior and posterior sheaths when possible. In three cases a Mayo⁴ repair was done. The anesthetic employed was local in 20 cases, general in ten and local supplemented by general in four. Twenty-eight of the 34 patients have been seen in the Follow Up Clinic; no recurrences have been observed.

Epigastric Hernia.—These herniae occurred above the level of the umbilicus and were small; some were multiple. Two patients required immediate operation, one for strangulation and the other for incarceration. Contrary to the opinion frequently held—that the epigastric hernia is often asymptomatic—these patients without exception gave symptoms of abdominal pain and discomfort. In two cases repair had been previously attempted. The method of repair was the same as in umbilical herniae. Fourteen of this group of cases have been followed; two (14.2 per cent) were not cured by operation. In one instance the patient was very obese and uncooperative; in the other the hernia had recurred previously.

Postoperative Ventral Hernia.—There were 48 ventral herniae in the series. In 12 cases the defect in the abdominal wall followed cholecystectomy, 16 followed drained appendectomy wounds and 20 occurred in lower midline incisions for pelvic operations. Six of the 48 herniae were recurrences. Twenty patients were over 50 years of age; 33 were definitely obese. Five of the ventral herniae were acute and four of the patients were poor operative risks. In no case was intestine resected. Reference has been made to the preoperative treatment given this group of patients. The peritoneum was opened in every case. We believe that careful closure of the peritoneum and overlapping of the fascia over it lends strength to the repair of the wound. As in other repairs, silk sutures were used without exception. There was one superficial wound infection in this group.

The anesthesia employed was general in 15; local in 23; spinal in six; and local supplemented by general in four.

All but seven of the 48 cases have been reexamined in the Follow Up Clinic. There were no recurrences. The seven patients who failed to return to the Follow Up Clinic reported by letter or telephone that they were well.

"Acute" Hernia.—In a recent analysis of a series of herniae treated at St. Vincent's Hospital (New York) O'Shea⁵ uses the term "acute" hernia to denote cases which required immediate operation. We employ this term to designate herniae in which there was incarceration or strangulation. An incarcerated hernia is not always considered an emergency, but immediate operation to rule out the possibility of strangulation is often indicated, as the transition from incarceration to strangulation and intestinal obstruction occurs too frequently to be disregarded. There were 56 acute herniae in this series; 30 were inguinal, ten femoral, nine umbilical, two epigastric and five postoperative ventral herniae. The bowel was found to be partially or completely obstructed in 19 instances.

It has been our policy first to relieve the intestinal obstruction in these patients. If the bowel is sufficiently viable it is returned to the abdominal cavity and the defect repaired. In femoral and inguinal herniae, if the bowel is gangrenous and resection is indicated, another abdominal incision is made and the bowel approached through it. A resection and anastomosis is performed or the bowel is merely brought to the surface of the abdominal wall, postponing the intestinal anastomosis until later.

That there were no fatalities in the acute herniae may, in part, be due to the plan of not imposing upon the patient, who is in poor condition, any procedure that may be done subsequently. A policy of early operation in hernia may in time eliminate entirely the mortality in these cases.

Postoperative Complications.—Immediate postoperative complications were noted in 27 cases. They appeared to have little relationship to the pre-operative condition or age of the patient, nor to the type of hernia or to the method of repair. Only three patients had postoperative pulmonary complications. In one of these, a lobar pneumonia occurred on the first postoperative day; however, it prolonged the usual period in bed by only three days; the other two cases were of a less serious nature. The low incidence of pulmonary complications was, in our opinion, due to the extensive use of local anesthesia.

There were seven cases of phlebitis of the lower extremities, two of these occurred in the extremity on the side opposite the operation. One had multiple pulmonary infarcts which prolonged her stay in bed to 45 days. In nine cases the wound became infected, exclusive of those known to be grossly infected at the time of operation. The infection was, fortunately, superficial in all nine instances and in none did it involve the fascial layer of the wound. There was one superficial slough associated with the repair: a large post-operative ventral hernia in which the skin had been too closely undercut. Hematomata of the cord were noted six times and in one case the clot was so large that, to evacuate it, the wound had to be reopened. One patient had a coronary occlusion from which he recovered.

Follow Up.—The late results presented in this paper are based upon observations made in the Surgical Follow Up Clinic. Hernia patients are requested to return to the clinic for observation at six month intervals; the majority are glad to cooperate. Telephone calls and letters are not considered in the evaluation of end-results. Each patient is examined by at least one

TABLE I
SUMMARY OF RESULTS IN FIVE HUNDRED HERNIA OPERATIONS

	Total Number of Cases	No. Examined in Follow Up Clinic	Number of Recurrences	Percentage of Recurrence
Indirect inguinal.....	303	253	6	2.37%
Direct inguinal.....	38	32	2	6.21%
Recurrent inguinal....	26	20	6	30. %
Femoral.....	33	26	3	11.5 %
Umbilical.....	34	28	0	0
Epigastric.....	18	14	2	14.2 %
Postoperative ventral .	48	41	0	0

surgeon other than the operator. The study includes a careful evaluation of the result of the repair and the determination of complaints and symptoms which might point to a recurrence or the presence of complications. By this means 83.2 per cent of the 500 cases have been followed from six to 24 months after operation (Table I).

A review of the literature shows that it is generally conceded that from 65 to 75 per cent of all recurrences are evident within six months after operation. Thus Erdman^{6, 7} states that 48 per cent of the recurrences in a large series of herniae took place within six months of operation and 80 per cent within a year. Masson,^{8, 9} at the Mayo Clinic, found that 73 per cent of the herniae which recurred did so within six months, and 84 per cent within one year after surgical repair. A report from the Brooklyn Naval Hospital¹⁰ shows that 65 per cent of all recurrences appeared within the first year after operation. Other reports¹¹ (Gibson and Felter,¹² Foss and Hicken,¹³ and R. French),¹⁴ offer similar figures.

CONCLUSIONS

(1) Five hundred consecutive herniae are reported, with brief descriptions of the therapy, and a careful study of the postoperative complications and the late results.

(2) It appears that with meticulous care, in every detail of the procedure, the incidence of infection may be lowered. It is also believed that local anesthesia decreases the number of postoperative pulmonary complications.

(3) In two types of herniae of this series, *i.e.*, the recurrent inguinal and femoral herniae, the incidence of recurrence is high.

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THE INTRAPERITONEAL APPROACH FOR REPAIR OF INGUINAL HERNIA*

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THE facility of an operation for the repair of inguinal hernia depends not only on the type and size of the hernia but also on adequate exposure of the structures involved. Large sliding herniae and some strangulated herniae with small, indurated rings require the best exposure obtainable. The importance of high ligation of the hernial sac is generally admitted. Increasing attention is being given to the transversalis fascia and to restoration of the internal ring.^{1, 2, 3, 4} Study of 100 cases in which the intraperitoneal approach was used suggests that better exposure of the internal ring is provided by this method and that it has value in some of the unusual or difficult herniae.

The intraperitoneal approach, as described by La Roque,⁵ exposes the internal ring from both the inner and outer aspects. It requires no different or additional skin incision and does not dictate the type of repair to be employed. The essential difference between the intraperitoneal and the usual approach is the addition of a muscle-split and peritoneal incision just above the internal ring. The neck of the sac may be removed and the internal ring repaired without danger to adjacent structures. The method of La Roque, slightly modified, was used in this series.

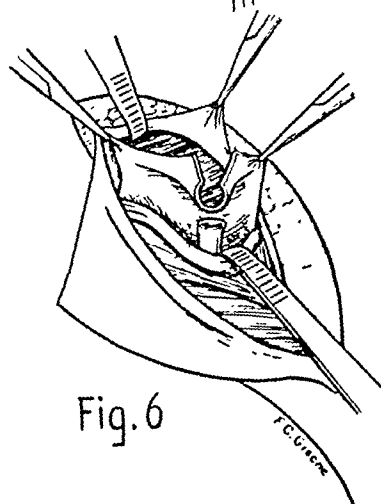
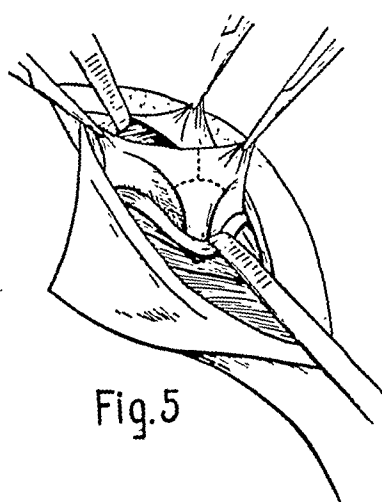
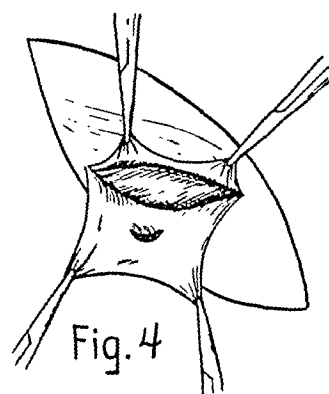
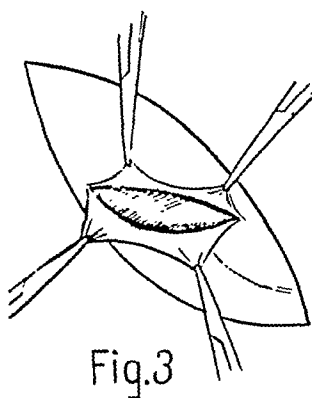
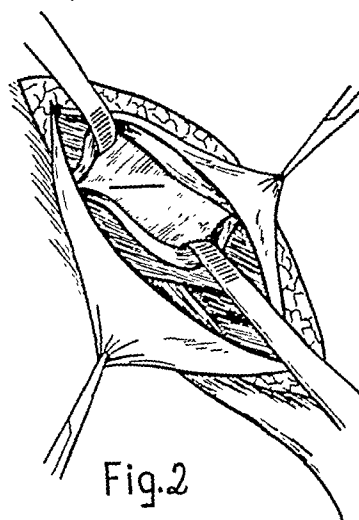
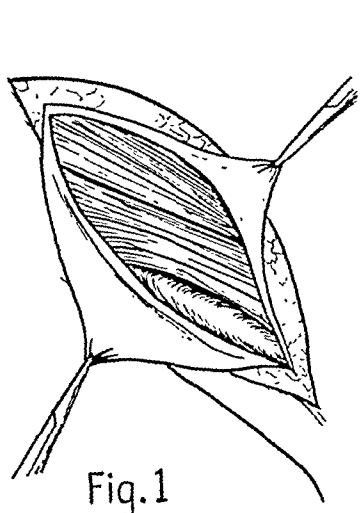
The idea of attacking the hernia from within is not new. It was suggested by Annandale⁶ in 1876, by Tait⁷ in 1883, and more recently by Jaboulay,⁸ Leriche,⁹ La Roque,⁵ Soresi,¹⁰ Banerjee,¹¹ Easton¹² and others. Some of the methods described call for additional skin incisions while others rely upon closure of the sac from the inner aspect without repair of the inguinal canal.

Technic of the Intraperitoneal Approach.—The skin incision is the one ordinarily used for operation on inguinal hernia. The aponeurosis of the external oblique is opened as usual and reflected to expose the internal oblique. The cremaster is seen masking the spermatic cord. The site for muscle-split is now selected. This is usually about one inch above the lower edge of the internal oblique (Fig. 1). This edge can be more readily felt than seen if the cremaster is well developed or if much fat is present. The muscle is then split parallel to its fibers and retracted to expose the transversalis fascia just above the internal ring (Fig. 2). The transversalis fascia and peritoneum are then incised as for appendectomy though at a somewhat lower level. The peritoneal cavity is now open at a point a little more than half an inch above the internal ring (Fig. 3).

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Up to this point the procedure has been that of an hernial incision to which a muscle-split has been added. The opening in the muscle is now gently



- FIG. 1.—Aponeurosis opened showing site of muscle-split.
FIG. 2.—Muscle retracted showing incision in transversalis fascia and peritoneum.
FIG. 3.—Peritoneum open above internal ring.
FIG. 4.—Lower peritoneal flap rolled out to show inner opening of indirect sac.
FIG. 5.—Neck of sac dissected free—dotted line indicates incision around it.
FIG. 6.—Peritoneum ready for closure after excising neck of sac.

retracted downward while the lower edge of the incised peritoneum is grasped and pulled outward. With a little blunt dissection this lower peritoneal flap is mobilized so that the abdominal opening of an indirect sac will roll

into view (Fig. 4). If a sac is found its interior is explored with the finger or an instrument. Contents are liberated and reduced into the abdomen. Adherent omentum is cut between ligatures and the adherent portion is left in the sac. If intestine is adherent in the sac its separation is delayed until the neck of the sac is opened, when it can be done under direct vision. If adhesions to the parietal peritoneum of the inguinal region are found they are divided.

The sites of possible direct and femoral herniae are now palpated from within the abdomen. In children the opposite inguinal region can often be reached by the exploring finger. If a direct or femoral hernia is found I prefer to lift the cord and open the peritoneum through the posterior wall of the inguinal canal.

The next step is dissection of the neck of the sac. The index finger is passed into the abdominal opening of the sac while traction is made on the lower peritoneal flap by an instrument held in the palm of the same hand. The neck of the sac is now freed by blunt dissection, pushing the fat away from the outside of the peritoneum in the place between the peritoneum and transversalis fascia. Sharp dissection may be needed at the medial side of the neck of the sac where transversalis fascia is firmly adherent. The cord structures are somewhat separated as they enter the canal. The vas deferens should be identified and guarded. The inferior epigastric vessels lie just medial to the vas deferens. As the neck of the sac is freed it will be drawn up into the wound (Fig. 5).

When the neck of the sac is entirely liberated from surrounding structures the peritoneum is slit from the original opening down to and around the neck of the sac. The sac is no longer continuous with the parietal peritoneum (Fig. 6). The sac may be dissected out and removed or part of it left if its bulk will not interfere with proper repair. The lower edge of parietal peritoneum, where the neck of the sac was excised, is further mobilized by blunt dissection, pulled upward and sutured to the upper edge of the original peritoneal opening. This line of closure may be fixed at a higher level if desired, by mobilizing the upper peritoneal edge before suturing. If adhesions have been separated inside the internal ring the damaged parietal peritoneum should be removed before closure. This insures smooth peritoneum at the internal ring and leaves no raw surface for the formation of adhesions.

Reconstruction of the internal ring is an important step in the repair. The transversalis fascia may be thin but it usually can be found when one becomes familiar with it as seen from this aspect. This layer should be sutured with reasonable snugness around the cord structures, taking care to avoid injury to the vessels and vas deferens. From this point on the repair may be done according to the choice of the operator. If desired, the muscle-split and peritoneal opening may be closed after the canal has been repaired.

In this series preference was given to the fascial type of repair, with imbrication of the aponeurosis of the external oblique beneath the cord. Sharp

dissection was used as far as possible and tissues were handled gently with careful retraction. Fine needles and fine absorbable sutures were used. An attempt was made to avoid tight sutures and tension on suture lines. Special attention was given to hemostasis and elimination of dead space. Plain double 0 catgut was used for ligatures. On most of the bilateral cases two operators worked simultaneously. The average patient was kept in bed for two weeks, those with fascial transplants for three weeks.

TABLE I

HISTORY AND OPERATIVE FINDINGS IN 100 INGUINAL HERNIAE

Age—over 50.....	13 per cent	Medium sac.....	30 per cent
Age—under 20.....	9 per cent	Small sac.....	27 per cent
Truss worn.....	17 per cent	Large sac.....	43 per cent
Indirect.....	87 per cent	Sliding.....	5 per cent
Direct.....	13 per cent	Recurrent.....	2 per cent
Bilateral.....	15 per cent	Strangulated.....	4 per cent

Observations.—The operative findings in this series of 100 cases in which the intraperitoneal approach was used are summarized in Table I. All but two were ward patients. Some of them were undernourished, but all were in good general condition at the time of operation. Seventy-eight per cent of the patients were between 20 and 50 years of age. Ninety-one per cent of the cases were followed for one and a half years. At the end of two years only 82 per cent could be located for examination.

TABLE II

TYPE OF REPAIR AND RESULTS

Modified Andrews.....	69 per cent	Deaths.....	0 per cent
Bassini or Ferguson.....	31 per cent	Wound infections.....	1 per cent
Cord transplanted.....	79 per cent	Recurrence known.....	2 per cent
Cord not transplanted.....	21 per cent	Examined after two years....	82 per cent
Fascial transplant.....	12 per cent	Fever* reaction (days).....	3.4

* Rectal temperature of 100 degrees or over.

The type of repair used and results obtained are shown in Table II. The incidence of postoperative pain, abdominal distention and urinary retention did not appear to be greater than after the usual operation. One wound was infected with staphylococcus aureus but the infection responded promptly to the Carrel-Dakin technic. There was no recurrence in this patient after two years. No evidence of nerve or muscle injury was seen in any case. Tissue destruction as indicated by postoperative fever and wound reaction did not seem to be increased. There were five respiratory infections in this series which raised the average number of days of postoperative fever (100 degrees or over, rectal) to 3.4. For the remaining 95 cases the average was 2.9 days. In 69 cases a fascial (modified Andrews) type of repair was used, with no known recurrence after two years. Among the cases where aponeurosis was not imbricated beneath the cord there were two recurrences.

The two recurrences in this series occurred, one at 16 months and the other at 18 months. Both of these herniae were originally indirect. Both recurrences were direct, coming through just lateral to the pubic tubercle. Both of them were reoperated upon by me. A Bassini type of repair had been performed in both instances. The transversalis fascia had not been plicated in the posterior wall of the canal. Dependence had been placed on the union of muscle to ligament. This line of union had stretched out to a thin layer of fibrous tissue with little resistance. There was no sign of muscle atrophy. There was no evidence of weakness in the region of the "muscle-split." Attention is called to the fact that both of these recurrences were among the early cases of the series when the "muscle-to-fascia" type of repair was employed and the medial part of the transversalis fascia was not tightened unless a direct hernia was present. In most of the subsequent operations this layer was plicated in the posterior wall of the canal and the internal ring was reconstructed. Only the fibrous portion of the conjoined tendon was utilized, dependence being placed on imbrication of the external oblique aponeurosis beneath the cord.

Sliding Hernia.—In the voluminous literature on hernia this type is rarely mentioned and recurrence statistics are even less frequently found. This may be due to the fact that the incidence of large sliding hernia is only about 2 to 5 per cent. There is little doubt, however, that in this group recurrence is relatively frequent.

Failure to cure sliding hernia may involve several factors. This type of hernia is not completely reducible and the contents of the sac are bulky. Therefore the defect in the abdominal wall is usually large, fascia split or thin and muscle displaced and atrophic. Proper reconstruction in such cases calls for a fascial transplant. If this is omitted recurrence may be expected in a majority of cases. The extensive dissection which precedes replacement of the prolapsed viscus may predispose to necrosis or infection. When the repair is completed the replaced viscus, usually cecum or iliac colon, lies just inside the weak spot ready to return to its former position at the first opportunity.

When a sliding hernia is encountered the intraperitoneal approach permits fixing the replaced bowel away from the hernial site without making another skin incision. Dissection may be done from above and below at the same time. When the parietal peritoneum has been sufficiently mobilized the viscus may be pulled upward so that when the peritoneum is closed it lies nearly two inches from the internal ring. Four large sliding herniae and one smaller one operated upon by this method have not recurred after two years.

Strangulated Hernia.—The intraperitoneal approach offers several advantages when dealing with a strangulated hernia. On opening the peritoneum above the internal ring one sees immediately what viscus is in the sac and proceeds accordingly. If it is safe to reduce the contents this can usually be done by gentle traction from the inside. Otherwise the peritoneum

may be slit from the original opening downward and the constricted internal ring cut under direct vision. The contents of the sac are inspected as they are replaced in the abdomen. If circulation is doubtful a tape may be passed around the bowel. This loop is reexamined after the repair and before the peritoneum beneath the muscle-split is closed. In the meantime the doubtful loop lies in its proper environment, protected from tension and chilling. Exposure is adequate for enterostomy or resection if indicated.

One patient in this series had a strangulated hernia the size of a large cantaloup. The internal ring was very small and tight. Within three minutes after the skin incision the contents of the sac (small bowel) had been replaced in the abdomen. This patient had no more postoperative reaction than the average elective case. Another patient was a man of 73 years, operated upon after this series was completed. His hernia had apparently been reduced the day before admission but pain and nausea persisted. A small mass could be felt beneath the muscles near the internal ring. At operation it was found that the contents (omentum) had been forced back out of the canal and lay in a dilated portion of the sac which was greatly indurated and adherent to the spermatic vessels and vas deferens as well as to the inferior epigastric vessels. This situation became relatively simple when the peritoneum was opened above the internal ring. Recovery of this patient was uneventful.

Incarcerated and Adherent Hernia.—When contents are adherent to a thin sac, back and within the internal ring, dissection may be tedious. All adhesions must be freed and no raw surface left after the sac is ligated. I have operated upon a number of recurrent herniae in which it seemed probable that such a raw surface adjacent to the internal ring was a factor in producing the recurrence. At times it may be difficult or impossible, from the classical approach, to mobilize the parietal peritoneum enough to permit removal of all damaged peritoneum when the sac is ligated.

When the intraperitoneal method is used this situation is under control. With the abdominal aspect of the internal ring in direct view adhesions are readily separated. If bowel is adherent within the sac, the sac may be opened at the internal ring above and through the canal below. Adhesions can then be freed by working alternately from either end. The neck of the sac is excised together with all doubtful peritoneum. The larger peritoneal defect thus produced can always be closed by mobilizing the parietal peritoneum.

Inguinal Hernia in Children.—It seems to be generally agreed that most herniae in children will be cured by high ligation of the sac alone. If this is true the less the cord is disturbed the better. A short incision may be made over the internal ring, the muscle split and peritoneum opened. The neck of the sac is excised. The sac itself may be split and left in place, if short. The sac can be easily separated from the cord and removed without disturbing the cremaster. This method leaves the cord undisturbed and makes certain high ligation of the sac. Six cases in this series were in chil-

dren. The average operating time was 12 minutes. There was very little postoperative reaction and none of the children needed opiates after operation.

There is another group of cases in which use of the intraperitoneal approach may be justified. It is becoming increasingly common for a man to request operation because he has been rejected for employment on account of hernia or apparent weakness in the inguinal region. Examination often shows nothing more than a slight impulse or an enlarged external ring. Again we may have a patient whose symptoms persist while the findings on examination are not conclusive. Often the man has been told that he will be given employment if his hernia is repaired. If we decide to operate upon one of these patients we are obligated not to weaken the inguinal region if no hernia is found. This can be done by the intraperitoneal method without disturbing the inguinal canal until it is evident that repair is indicated. The peritoneum can be opened above through a two inch skin incision. If a hernia is found the incision may be extended downward and the inguinal canal opened.

COMMENT.—The intraperitoneal approach, by adding a muscle-split to the usual incision, permits inspection or palpation of all inguinal hernia sites from within the abdomen. Its chief value lies in the fact that direct exposure of the internal ring is obtained without prolonging the operation or increasing the morbidity. The operation may be started in the usual manner. If the sac is not readily located or if the sac or its contents are unusually adherent the muscle may be split above the internal ring and the peritoneum opened in less than two minutes. The internal opening of the sac is found at once and its extent and contents noted. The adherent sac can be dissected more easily after its neck has been isolated and cut away from the parietal peritoneum. High ligation of the sac is made certain. In fact, the peritoneal neck of the sac and with it all raw surfaces which might lead to formation of adhesions is completely eliminated, leaving smooth peritoneum at the internal ring. Dissection around the neck of the sac is done under direct vision with the cord structures in full view. The internal ring may be reconstructed without damaging the cord or inferior epigastric vessels.

Easton,¹² commenting upon the operation advocated by La Roque, says: "Theoretically this operation seems to be subject to the disadvantage that it does not permit inspection of all possible hernial sites. It also has a tendency to weaken adjacent muscular structures and fails to strengthen the region of the internal opening of the hernia." I found no difficulty in any of the 100 cases in this series in inspecting the site of an indirect or direct hernia or in palpating the site of a femoral hernia. If a direct or femoral hernia is present I prefer to open the peritoneum through the posterior wall of the inguinal canal. In my cases there was no evidence that adjacent muscular structures had been weakened. I see no reason why this should happen if nerves are preserved and muscles are retracted gently. Concerning repair of the inguinal ring, I can say with certainty that the method used in this series gives excellent exposure of the internal ring and greatly facilitates its reconstruction.

This operation seems to be most useful in the unusual case, whether this be determined before operation, as in a strangulated hernia, or after the operation has begun and the ordinary approach found inadequate. If, on opening the sac, a sliding or unusually adherent hernia is found, time will be saved and a better result obtained by opening the peritoneum above. The operator should be able to visualize the anatomy of the inguinal region from the inner aspect, especially the transversalis fascia and position of the cord structures and inferior epigastric vessels at the internal ring. More than half the operations in this series were done by house surgeons under supervision.

CONCLUSIONS

The intraperitoneal approach for the repair of inguinal hernia, as described by La Roque, is a useful procedure with which the surgeon should be familiar.

It is suggested that this method be reserved for the unusual hernia or added to the classical operation when difficulty is encountered.

Direct exposure of the internal ring permits excision of the neck of the sac and accurate reconstruction of the ring itself.

The method has been found especially useful in operating upon strangulated or large sliding herniae.

The morbidity and recurrence rates were not increased in 100 cases operated upon by this approach.

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CORRELATION OF PATHOLOGIC AND ROENTGENOLOGIC FINDINGS IN TUBERCULOSIS AND PYOGENIC INFECTIONS OF THE VERTEBRAE

THE FATE OF THE INTERVERTEBRAL DISK

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ACCURATE interpretations of roentgenographic findings in diseases of the spine depend upon knowledge of the normal anatomy of the vertebrae and of the pathologic changes which may arise in them.

The studies of Schmorl³⁰ have helped to clarify our knowledge of the normal and pathologic anatomy. The difficulty in obtaining permission for the removal of the spine at necropsy and the infrequency of operative attack upon the vertebral bodies have resulted in a marked lack of reports of studies of vertebral pathology in the English literature. The fate of the radiolucent intervertebral disk in infections of the spine has been postulated upon the basis of clinical and roentgenologic observations.

Phemister²⁷ has shown that the contacted hyaline cartilages of joints of the extremities resist destruction from tuberculosis more effectively than from pyogenic infections. In our studies of the pathology of the spine we have found evidence that despite their differences in structure and function the intervertebral disk reacts to infections much as does the cartilage of the knee or the hip joint. An attempt has been made in this study to correlate the pathologic and roentgenologic findings in tuberculosis and pyogenic diseases of the spine.

Anatomic Considerations.—An individual vertebra is formed from three primary and five secondary centers of ossification. The primary centers, one each for the vertebral body and for each half of the neural arch, are present at birth. The secondary centers develop in the tip of each transverse process, the tip of the spinous process, and the marginal limit of each metaphysis of the vertebral bodies. These latter centers appear at puberty, may not fuse until the age of 25, and are referred to as the "epiphyseal ring." They are the rudiments of true epiphyses which completely cap the ends of the bodies of the vertebrae in lower animals, including the dog, rat, and cat.

Lexer and more recently Wagoner and Pendergrass³⁴ have studied the blood supply of the vertebral body and have shown that it is richly supplied with nutrient arteries which penetrate the cortex of the body into the spongiosa from all sides but do not cross the articular surfaces. The venous blood is collected into large sinusoids which, in turn, empty into the arachnoidian veins, from which the flow is directed in the lumbar region into

the inferior vena cava, in the thoracic into the azygos system, and in the cervical region into the main tributaries of the superior vena cava.

The structure of the normal intervertebral disk varies with the age of the individual. The fibrocartilaginous annulus blends intimately with the hyaline cartilage plates above and below and, with them, encloses the oval nucleus pulposus. The nucleus consists of an interlacing matrix of fibrous tissue and fibrocartilage, within the meshes of which is the semigelatinous nuclear substance which helps to maintain the form and contributes greatly to the resiliency of the normal disk. This material conforms to the law of fluids and

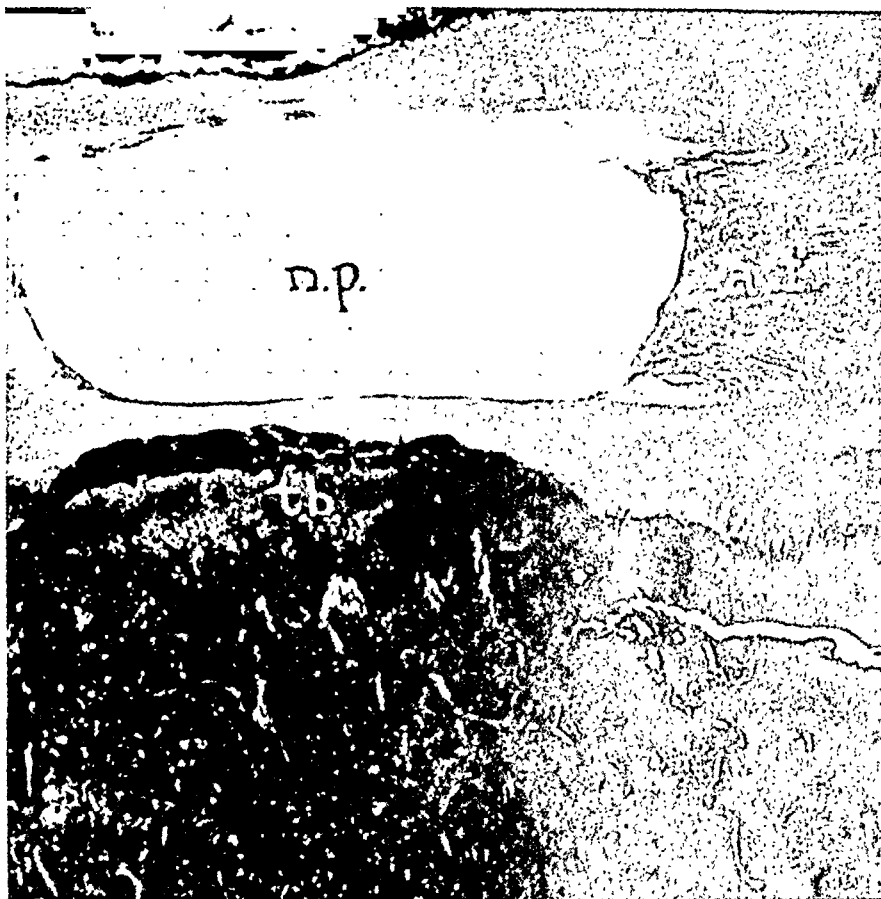


FIG. 1.—Tuberculous granulation tissue (t.b.) has extended between cartilage plate (c.p.) and bone, with gradual erosion of the cartilage. The nucleus pulposus (n.p.) and the annulus (a.f.) show no evidence of invasion.

is incompressible. Narrowing of the disk must be attended by dehydration, extrusion, or destruction of all or a part of the nucleus pulposus.

Blood vessels are not present in the adult intervertebral disk. Nutrition is supplied through the lymphatic system. Jung and Brunschwig¹⁵ were able to demonstrate nerve fibers in the paravertebral ligaments, but none were found in the intervertebral disk.

Vertebral Tuberculosis.—Tuberculosis of a vertebra most commonly arises from a hematogenous implant in the spongiosa or compacta of the body, secondary to a lesion of lung or alimentary tract. The rare condition of vertebral infection by direct extension from tuberculous retroperitoneal lymph nodes has been reported by Fraser¹⁰ and by Capener.³ Harris¹³

reported tuberculous bacillema and bacilluria in cases of bone and joint tuberculosis.

Judging from roentgenograms of early cases and from the available pathologic studies of early lesions, the infection nearly always begins within the body of the vertebra. Whether or not it is a primary metaphyseal lesion along the upper or lower limit of the body as in the diaphysis of a long bone or whether it begins in the spongy bone away from the articular ends is not definitely known. The case shown in Fig. 1 supports the metaphyseal theory. Kaufmann¹⁶ believes that tuberculosis of a vertebra begins usually in the anterior portion of the body beneath the cartilage plate, but in some instances centrally, producing a diffuse caseous internal osteitis.

Keyes and Compere¹⁷ showed that the adult disk is devoid of blood vessels and that nutrition must be maintained through osmosis and intercellular lymph spaces. No lymph vessels could be identified communicating from the vertebral body to the nucleus pulposus. Tuberculosis of the intervertebral disk would seem to be possible only by extension from foci in contiguous structures.

Thrap-Meyer,³² after citing his own cases, and others from the literature, of multiple hematogenous infection in tuberculous spondylitis, stresses the infrequency of this occurrence.

PART I

PATHOLOGY OF VERTEBRAL TUBERCULOSIS UNCOMPLICATED BY SECONDARY PYOGENIC INFECTION

No case of primary tuberculosis of the vertebral appendages, the arch or the pedicles has been found in our series of cases, and we believe it to occur very rarely. Phemister and Hatcher²⁷ have reported their studies of tuberculosis of the extremity joints and have shown that tuberculosis granulations from an epiphyseal focus in adults may slowly erode the cartilage plate and penetrate into the joint. Figure 1 illustrates a similar process in the vertebra of an adult with slow erosion into the cartilage from a lesion in the metaphysis of the body. Such a lesion may be too small to be recognized in the roentgenogram until after prolapse of the nucleus pulposus and destruction of the disk, although the primary focus is definitely osseous.

The following cases, together with the necropsy findings, illustrate the clinical and pathologic nature of vertebral tuberculosis in children.

Case 1.—R. C., male, age 14, was admitted to the University of Chicago Clinics December 9, 1931, with a diagnosis of tuberculosis of the spine and right hip. The initial focus had been in the vertebral column and was first noted in October, 1923. Arthrodesis of the spine was performed in November, 1924, with clinical evidence of healing.

Tuberculosis of the right hip had been diagnosed in 1929 and abscesses had developed over the greater trochanter. The hip was successfully fused September 25,

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1931. In July, 1932, the patient developed signs of meningeal irritation and died August 5, 1932, at the age of 15, of tuberculous meningitis. At necropsy a segment of the spine from thoracic 5 to lumbar 1 inclusive was removed.

Pathology.—The gross sagittal section of the spine (Fig. 2a) includes the vertebrae from T 5 to L 1. From T 6 to T 12, the arches are fused into a solid bony plate. The fragments of the vertebral bodies of T 8 and T 9 have fused together. The centrum of T 7 shows a slight loss of contour.

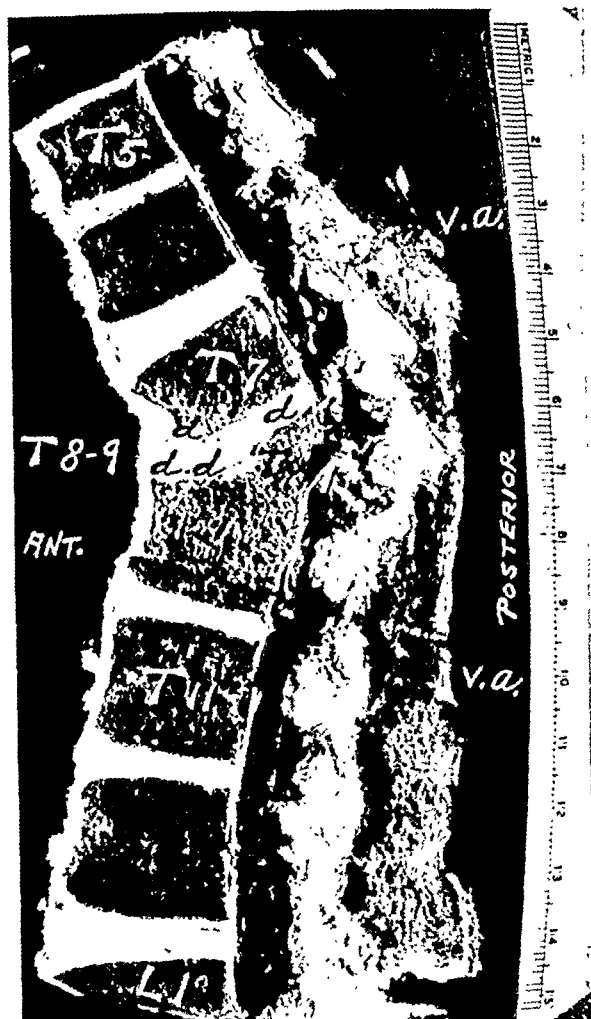


FIG. 2a.—(Case 1) Age 15. Tuberculosis, healed. Photograph of split spine section from T 5 to L 1. At the apex of the kyphos are two small wedge-shaped bony masses, remnants of the bodies of T 8 and T 9. Portions of disk T 7-8 (d) and disk T 9-10 (d.d.) may yet be identified. The vertebral arches (v.a.) show surgical fusion from T 6 to T 12.

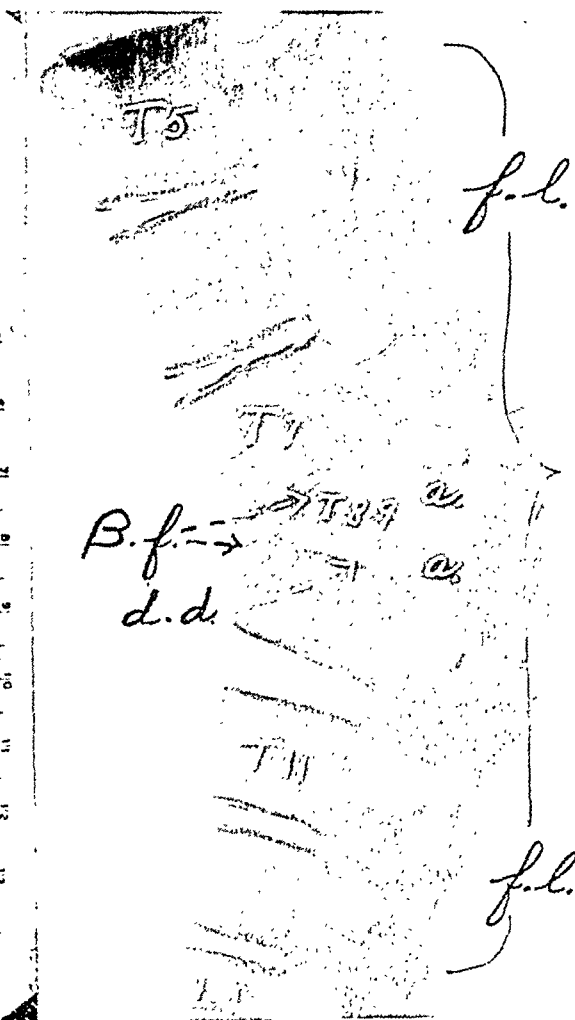


FIG. 2b.—Roentgenogram of gross specimen. Bony fusion (b.f.) between T 7 and the collapsed mass of T 8 and T 9 is almost complete and partial fusion (b.f.) is present across the intervertebral space of T 9 and 10. The posterior two-thirds of this disk (d.d.) is persistent but narrowed. No evidence of active tuberculosis is seen in either illustration. *Note.*—This is a healed case of tuberculosis of the spine and does not show the sclerosis, sequestration or other presumptive evidence of pyogenic infection which was recently described by Finder in a case of vertebral tuberculosis with multiple abscesses and discharging sinuses. This case and Cases 7, 8 and 9 indicate that changes, which Finder thought to be brought about by the healing process in vertebral tuberculosis, obtain only when there is a dual infection.

The disk between the wedged vertebrae and the centrum below has been completely disrupted in its posterior portion and anteriorly represents the remnants of disk T 8-9 and T 9-10. Disk T 7-8, at the cephalic margin, appears well preserved. In this gross specimen there is no recognizable area of disease.

The roentgenogram of the split spine section (Fig. 2b) shows the fused and wedged



Fig. 3c.—Section through the distomedial portion of T 8 and T 9, with the surrounding disk substance. There is some preservation of the cartilaginous (c.p.) and fibrous tissue (a.f.) of the disk even after extensive destruction of this part of the spine. There is no microscopic evidence of active tuberculosis (X210).

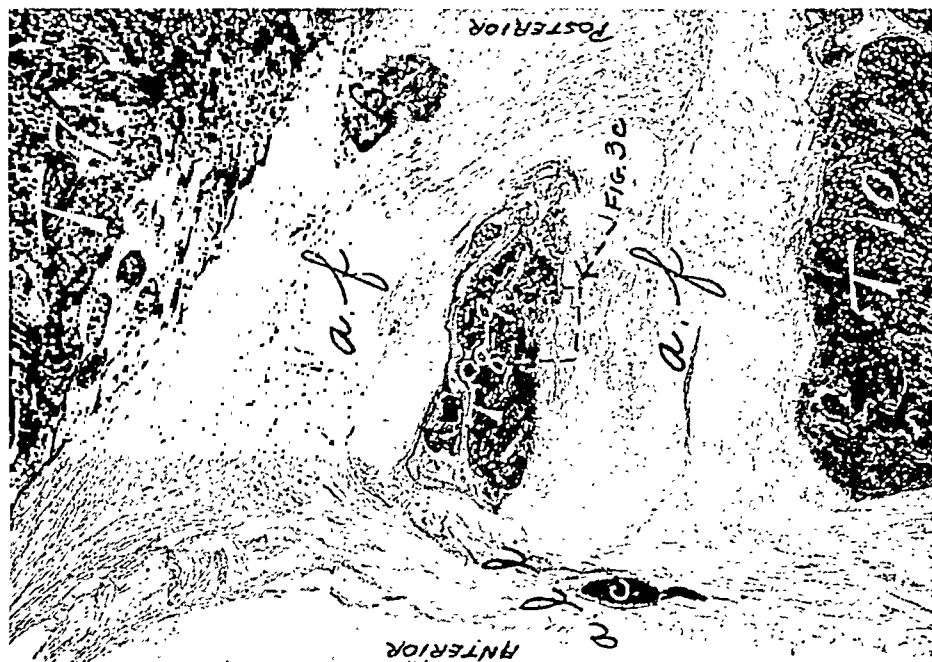


Fig. 3b.—A higher magnification showing the remnants of the anterior portion of T 8 and 9, with the fibrous element of the adjacent disks (a.f.). A small area of calcification (c) is present in the anterior longitudinal ligament (a.l.). Ossseous invasion of disk substance may be noted at (b.) (X10).

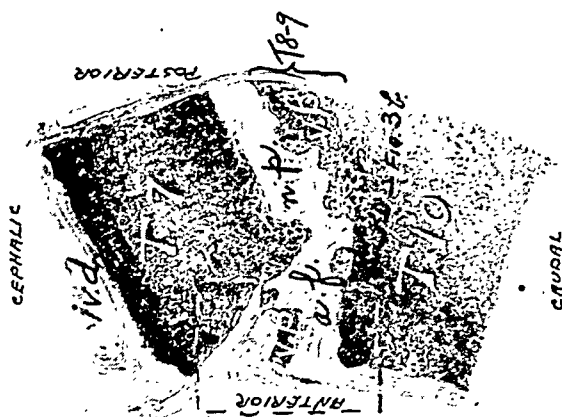


Fig. 3a.—(Case 1) Age 15. Tuberculosis. Centra T 7 to T 10 with intervertebral disks are included. The high degree of wedging of the bodies of T 8 and T 9 (v.b.) is well illustrated. Disk T 6-7 (v.d.) is grossly intact eight years after spinal fusion. A part of the annulus (a.f.) and nucleus pulposus (n.p.) of disk T 7-8 has survived the infection (X2).

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remnants of the bodies of T 8 and T 9. Partial osseous fusion exists between these crushed centra and the vertebrae above and below. Both proximally and distally, however, portions of the intervertebral disk space of T 7-8 and T 9-10 may be identified. All other vertebrae and disks present an essentially normal appearance. The laminae appear to be fused. There is no roentgenographic evidence of active tuberculosis. The vertebral bodies of T 7 to T 10 are included in the microscopic section (Figs. 3a, b, and c). Normal hematopoietic marrow is present throughout, even in the

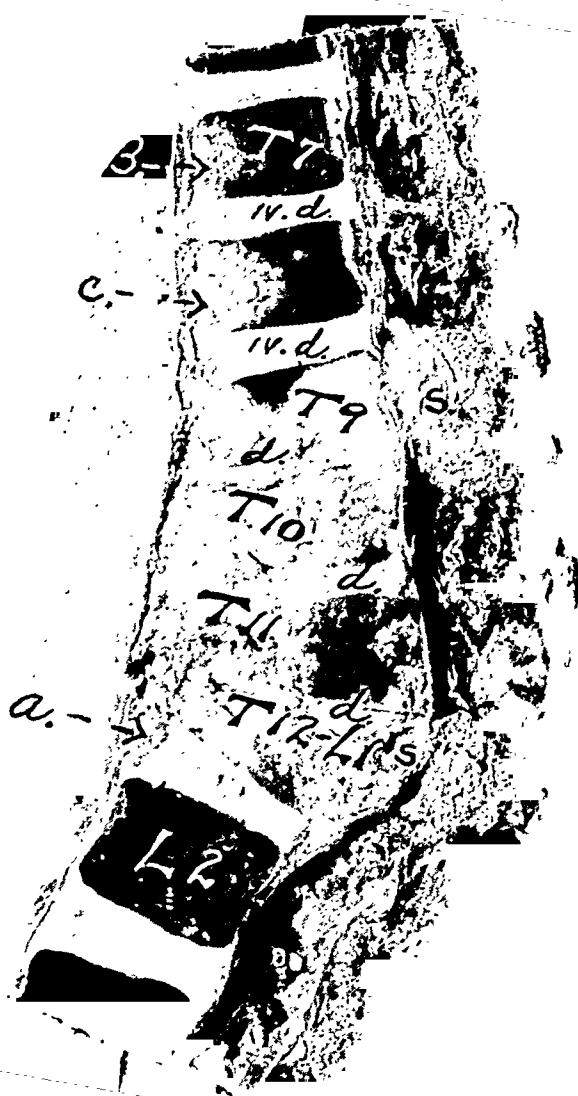


FIG. 4a.—(Case 2) Age 6. Tuberculosis. Photograph of split section from T 7 to L 2, with portions of T 6 and L 3. The centra from T 9 to L 1 have collapsed to form a caseous mass, in which small remnants of the disks (d.) are still visible. Beginning anterior erosion of disk L 1-2 is seen at (a), while similar invasion (B.c.) is occurring into the bodies of T 7 and 8. Caseous debris is present in the spinal canal at the level of T 9 and T 12 (s.).

FIG. 4b.—This roentgenogram of the split section shows necrosis and collapse of the centra from T 9 to L 1. Parts of three intervertebral spaces (d.) persist. Note anterior erosion (a.b.) of the bodies of T 7 and T 8 and backward protrusion of partially calcified material into the spinal canal (c.).

crushed remnant of T 8 and 9. There is no inflammatory process or fibrous tissue reaction within the bodies. The intervertebral disk T 6-7 appears to be normal. The disks between T 7 and 8 and T 9 and 10 exist as irregular fibrous bands with a few areas of cartilage. Disk T 8-9 has been completely disrupted. The nucleus pulposus material of disk T 7-8 has been reduced in quantity, either by dehydration or loss into

the spongiosa or ligaments. The hyaline cartilage plates of the posterior fourth of the disk of T 7-8 are still intact, while those of disk 9-10 have almost completely disappeared. A small calcified area is present within the substance of the anterior ligament slightly below the level of the collapsed centra. No area of active tuberculous tissue could be found in the sections.

COMMENT.—This represents a case of healed tuberculous spondylitis of nine years' duration, in which meningitic infection occurred, probably not from the spine but from a hematogenous implant within the spinal canal.

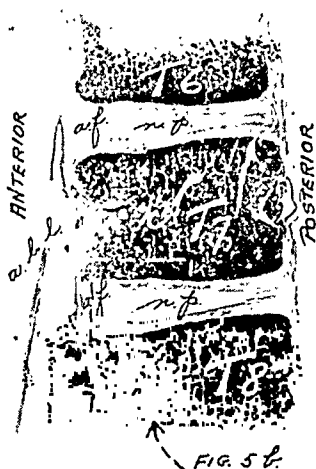


FIG. 5a.—(Case 2) Age 6. Tuberculosis. The centrum of T 7, with a portion of T 6 and T 8. The annulus (a.f.) and nuclear structure (n.p.) of the disks are well preserved. Caseous debris has spread beneath the anterior ligament (a.l.l.) with invasion of T 7 and T 8 (c.) (X2).



FIG. 5b.—A portion of disk T 7-8 and the adjacent vertebral bodies. The annulus fibrosus (a.f.) and nuclear structure (n.p.) of the disk are intact. The areas of caseation (t.c.) in the centra extend to, but do not cross, the plates of hyaline cartilage (c.p.). There are many tubercles, most of which are undergoing central caseous necrosis (X13).

The tuberculosis of the hip was found to be quiescent but not healed and this may have been the source of the meningeal infection. There is collapse of two of the centra, with crowding together of the arches. Osseous destruction is more marked than is that of the fibrous and cartilaginous portions of the intervertebral disks.

Case 2.—E. H., male, age 6, was admitted to the University of Chicago Clinics February 26, 1932. The onset of symptoms was six months previous to admission. At the age of five and one-half years a definite kyphos was noted in the lower thoracic spine associated with night cries and daily elevation of temperature. The patient also had a left otitis media, which was probably tuberculous.

The course was continually downhill in spite of complete bed rest, immobilization,

and supportive treatment. No operation was performed. Tuberculous meningitis was diagnosed in June, 1932, and the patient died June 24, 1932, at the age of six years, nine months. A segment of the spine from T 6 to L 3 was removed at necropsy.

Pathology.—The split section (Fig. 4a) includes eight vertebrae from T 6 to L 3. The infection has spread by extension both upward and downward beneath the anterior ligament which is raised from the centra over the infected bodies by caseous material. Five vertebrae (T 9 to L 1) are almost completely replaced by caseous necrosis and their partial collapse anteriorly has produced mild kyphosis. Caseous material has extended into the spinal canal at L 1 and also above the level of the kyphosis. The anterior portions of the intervertebral disks show invasion by direct extension of the infection from the tuberculous abscess.

A roentgenogram of the section (Fig. 4b) shows partial destruction or collapse of the centra from T 9 to L 1, with indefinite preservation of the intervertebral spaces. The disk space between T 12 and L 1 has been completely lost and the bodies are united in a caseous and calcareous mass which is encroaching upon the spinal canal. Roentgenographic evidence of anterior invasion is seen in the centra of T 7 and T 8.

A satisfactory microscopic section through the most necrotic vertebrae could not be made. The microscopic studies include sections of the bodies of T 6, 7 and 8, with their intervening disks (Figs. 5a and b). At the level of disk T 6-7 the anterior ligament is firmly attached to the annulus, marking the upper limit of spread of the infection.

Many tubercles may be seen in the cancellous bone of T 7 and T 8 showing circumferential spread and destruction of trabeculae. The anterior part of the centrum of T 8 exhibits involvement from the abscess beneath the paravertebral ligament in a wedge-shaped area of necrosis separated from the living osseous tissue by a wall of granulations. The centrum of T 7 has been similarly invaded.

The cartilage plates and the intervertebral disks appear to be grossly normal. At the posterodistal margin of disk T 7-8 a microscopic fissure may be seen in the cartilage plate with beginning invasion of fibroblasts and leukocytes.

COMMENT.—This case demonstrates the spread of vertebral tuberculosis by extension beneath the anterior paravertebral ligament, with involvement of the centra and to a lesser degree destruction of the intervening disks by anterior invasion.

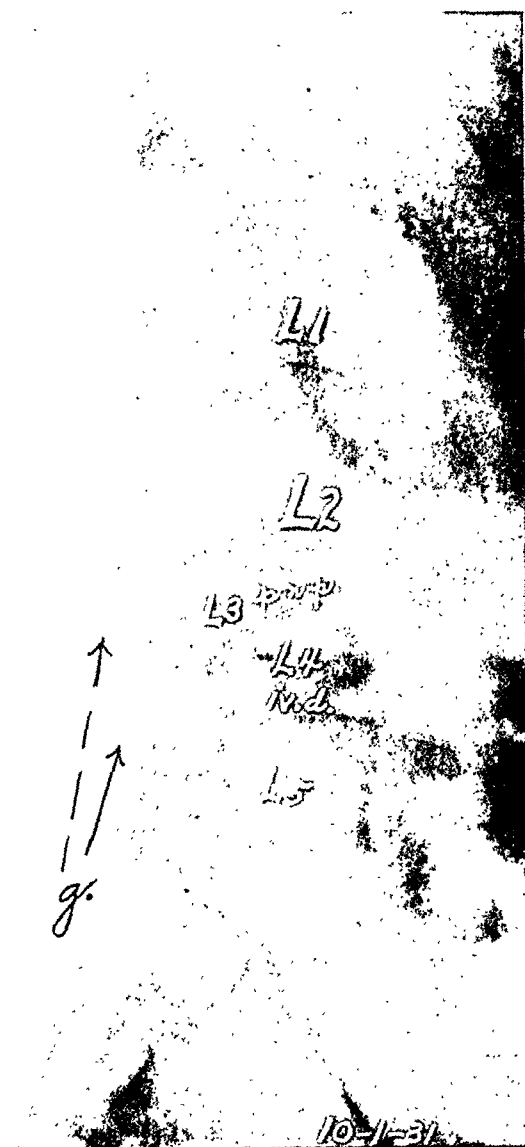


FIG. 6.—(Case 3) Age 13. Tuberculosis. Roentgenogram taken October 1, 1931, a month before the second spinal fusion and two months, three days antemortem. The bodies of L 2, 3 and 4 are wedged and have undergone partial osseous fusion, but with some preservation of the intervertebral space between the anterior edges of L 2 and L 4. The nucleus pulposus (p.n.p.) of disk L 2-3 has prolapsed into the centrum of L 2. Disk space L 4-5 (iv.d.) appears uninvaded. A portion of the graft (g.) may be identified.

Case 3.—C. C., female, age 13, was admitted to the University of Chicago Clinics February 24, 1931, because of tuberculosis of the second, third, and fourth lumbar vertebrae first diagnosed at the age of six years.

Treatment had consisted of intermittent periods of immobilization in a plaster encasement or on a Bradford frame. An Albee type of fusion was performed March 2, 1931. At operation the spines and laminae of the lumbar segments were found to be extensively eroded and replaced by tuberculous caseation. The bone graft was attacked by the infection and a fracture then occurred at the site of maximum splinting stress. A second spinal fusion operation was performed November 11, 1931 (Fig. 6), but the patient died of tuberculous meningitis December 4, 1931. A segment of the spine from T 11 to L 5 was removed at necropsy.



FIG. 7a.—(Case 3) Age 13. Tuberculosis. Shows the centra of L 2 and 4 and a part of L 5. The small remnant of L 3 is not included in the section. Three small centers of ossification (e.) representing the epiphyseal ring are seen in disk L 4-5 (iv.d.) (X2).



FIG. 7b.—Includes L 4 with the adjacent disks and a small portion of L 2. The persistent annulus (a.f.) and the prolapsed nucleus pulposus (p.n.p.) of disk L 2-3 are noted (X10).

Pathology.—Vertebral bodies L 2, 3 and 4 are compressed both in the anteroposterior and lateral diameters. Disk L 3-4 has been destroyed and there is fibrous union between the two centra. Disk L 2-3 is still present anteriorly but partial destruction has occurred in its posterior portion. Disks L 1-2 and L 4-5 appear to be intact.

The microscopic section includes a portion of L 2 and 5 and all that remains of the bodies of L 3 and 4 (Fig. 7a and b). Tuberculous granulation tissue can be identified in the anterior paravertebral ligament in contact with the centra of all of these vertebrae. Disk L 2-3 has been broken through, with herniation of the nucleus pulposus into the spongiosa.

COMMENT.—This represents a case of vertebral tuberculosis with destruction of two adjacent centra and preservation of a portion of the corresponding disk elements. Although the pedicles, laminae and spinous processes of the diseased vertebrae show caseous tuberculous necrosis, greater destruction of the centra leads us to postulate that the appendicular involvement was secondary to that in the bodies. Erosion of the inferior cartilage plate of L 2 was followed by extrusion of a portion of the nucleus pulposus into the necrotic tuberculous spongiosa.

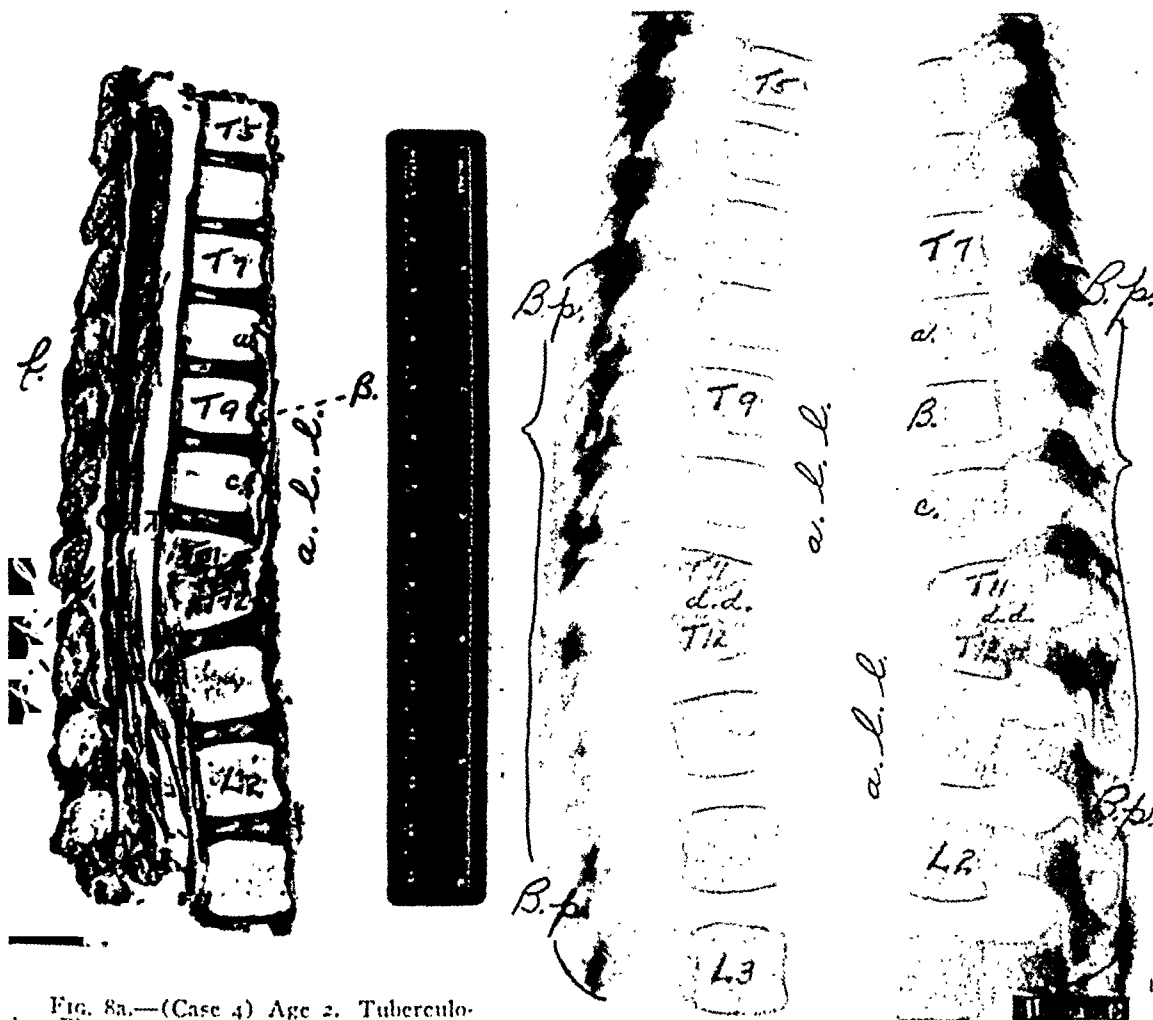


FIG. 8a.—(Case 4) Age 2. Tuberculosis. Photograph of split section from T 5 to L 3. The bodies of T 11 and T 12 are wedged, with disruption of the disk and loss or extrusion of the nucleus pulposus. Abscess or debris has migrated beneath the anterior ligament with invasion of three centra (a.b.c.). The posterior ligament (p.p.l.) is elevated over T 11 and T 12.

FIG. 8b.—Roentgenogram of section shown in Fig. 8a. The collapse and wedging of T 11 and T 12 are shown, with the irregular narrowing of the intervertebral space (d.d.). There has been anterior invasion of the centra of T 8, 9 and 10 (a.b.c.). From T 7 to L 3, the lamina are fused into a solid bony plate (b.p.).

Case 4.—J. L. M., female, age 16 months, was admitted to the University of Chicago Clinics May 24, 1934. She had been treated for one year for acute bilateral miliary pulmonary tuberculosis. There was a history of direct contagion from the mother who had an active pulmonary lesion. An abscess shadow was noted about the lower thoracic spine in the chest roentgenogram of May, 1934. Lateral roentgenograms of the spine showed a definite destructive lesion in the eleventh and twelfth thoracic vertebrae. A review of earlier roentgenograms showed that this abscess shadow, although not previously discovered, had been present and enlarging for at least six months.

A spinal fusion operation was performed June 4, 1934. The patient made an uneventful postoperative recovery, but two months later developed signs of meningeal irritation and subsequently died of tuberculous meningitis October 12, 1934, at the age of two years and ten months. A section of the spine from the fifth thoracic to the third lumbar vertebrae was removed at necropsy (Fig. 8a).

Pathology.—There is no gross evidence of direct extension of tuberculosis from the diseased spine or abscess through the dura and into the spinal canal. The spine is adequately splinted by the fusion operation.

Contiguous portions of the centra of T 11 and 12 are collapsed and somewhat wedged. The intervening disk has been almost completely destroyed and the intervertebral disk space is represented by a single abscess cavity, about the margins of which remnants of the annulus fibrosus and cartilage plate can still be identified. Posteriorly, this abscess presses upon the dura, and the posterior ligament has been raised from the diseased centra by the migration of pus and débris beneath it (Fig. 8a).

The anterior paravertebral ligament has been elevated from the vertebral margins from disk T 7-8 to disk T 12 by upward extension of the abscess. Definite invasion of the anterior margins of the centra of T 8, 9 and 10 can be seen, but the corresponding intervertebral disks are intact.

The roentgenogram of the split spine section (Fig. 8b) shows wedging and triangularization of the shadows of the bodies of T 11 and T 12, with disruption of the intervening disk space. The areas of anterior invasion of T 8, 9 and 10 noted in the split spine sections are shown in the roentgenogram. The laminae from T 8 to L 3 are fused into a strong plate of bone.

The microscopic sections include the centra from T 8 to L 1, with their intervening disks (Figs. 9a, b and c). A few fragments of hyaline cartilage plate and portions of the annulus fibrosus may be identified in the borders of the cavity between T 11 and T 12. The anterior ligament has been raised from the vertebral margins by tuberculous exudate and granulation tissue containing tubercles lines the abscess cavity.

The trabeculae of T 11 and 12 are atrophic about the margins of the old disk area and the normal marrow has been replaced by diffuse fibrous tissue. The anterior invasion into the centra of T 8, 9 and 10 is by direct extension from the tuberculous abscess. Complete preservation of the intervening disks is again noted.

COMMENT.—This constitutes a study of a case of acute vertebral tuberculosis. Extension of an abscess into the spinal canal without perforation of the dura has been demonstrated. The meningeal infection was diffuse and generalized and probably occurred from hematogenous extension, or by direct spread of organisms through the dura by the lymphatics at level T 11 and 12. The anterior invasion of three vertebral bodies, with complete preservation of the intervening disks shows the usual method of spread of the disease in the spine and again demonstrates the tendency of tuberculosis to invade and necrose cancellous bone more readily than mature fibrous tissue or cartilage.

DISCUSSION: PART I.—This pathologic study of four cases of tuberculosis of the spine indicates that the finding that cartilage is less readily destroyed by tuberculous exudate, than is bone, is as true of the fibrous and cartilaginous portions of the intervertebral disk as it is of the hyaline cartilage of the knee or hip joints. Remnants of intervertebral disk substance may persist after the contiguous vertebral bodies have been disrupted by the tuberculous infection.

Fig. 9a.—(Case 4) Age 2. Tuberculosis. The infection has been most active in the bodies of T 11 and T 12, with destruction of a large part of the intervening disk (d. iv. d.). A tuberculous abscess and invaded beneath the anterior ligament centra of T 8, 9 and 10 (a.b.c.) (X2).

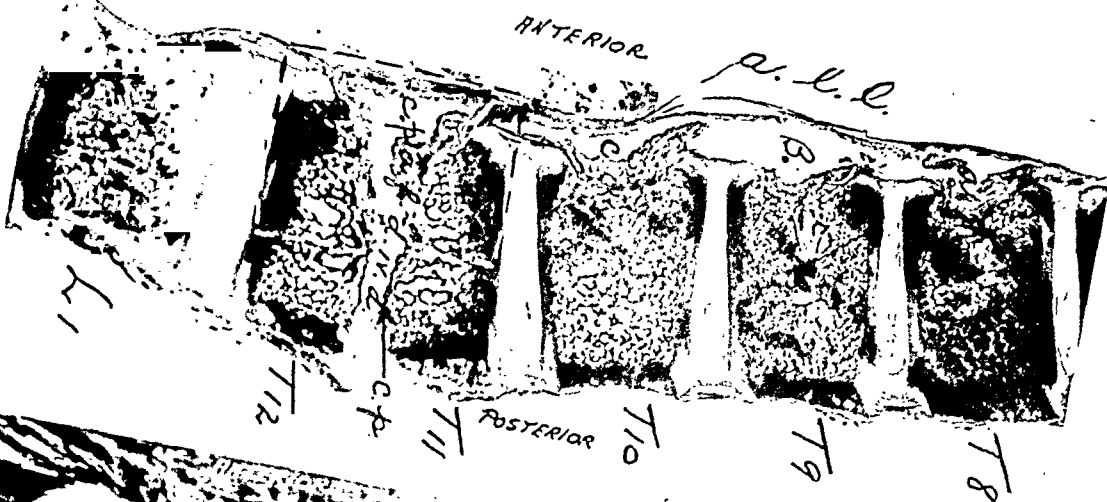


Fig. 9b.—Section through the anterior portion of disk T 11-12 which has been replaced by a tuberculous abscess (t.a.) in the walls of which are many tubercles. The cartilaginous portion of each adjacent centrum has been invaded. A portion of the annulus (a.f.) persists and a few small remnants of the cartilage plates are noted (a.p.) (X10).

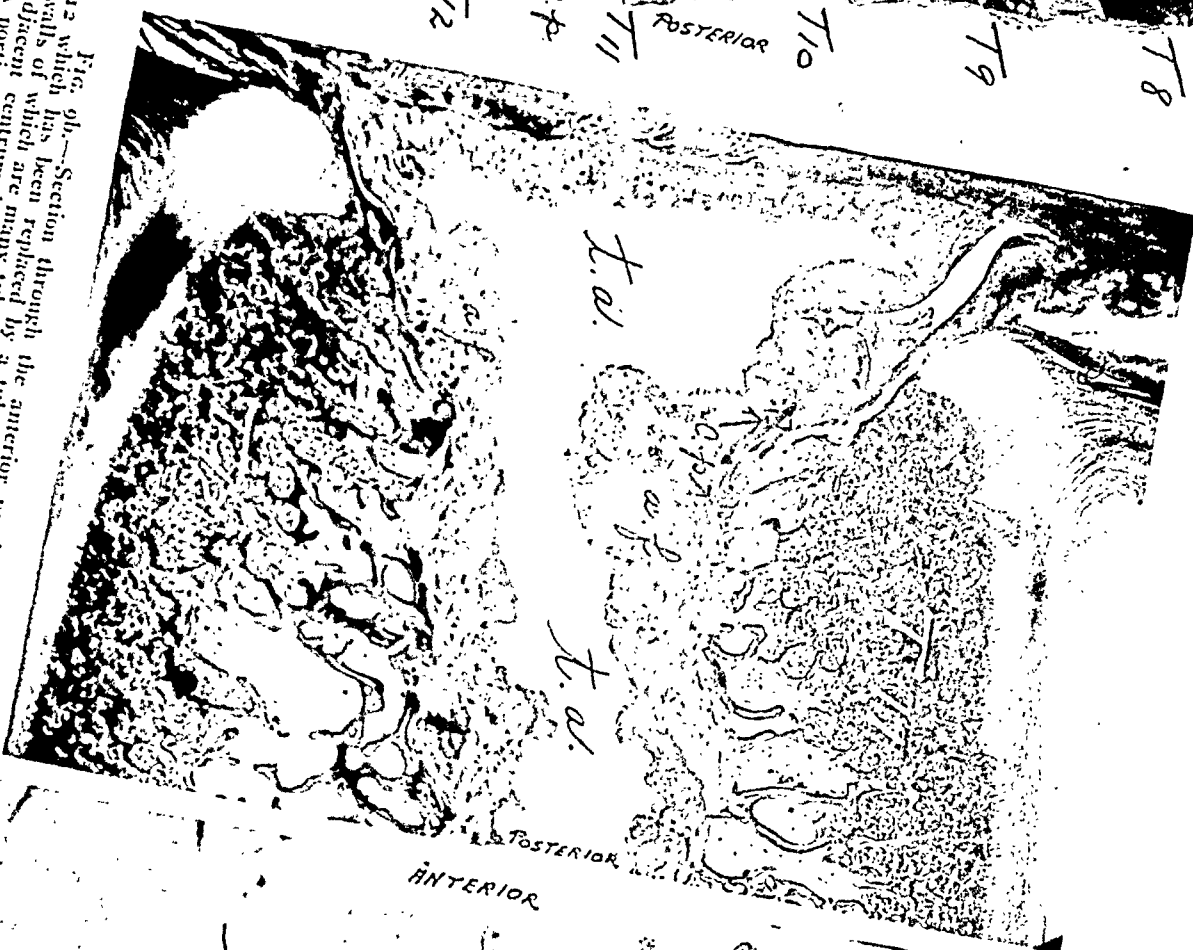
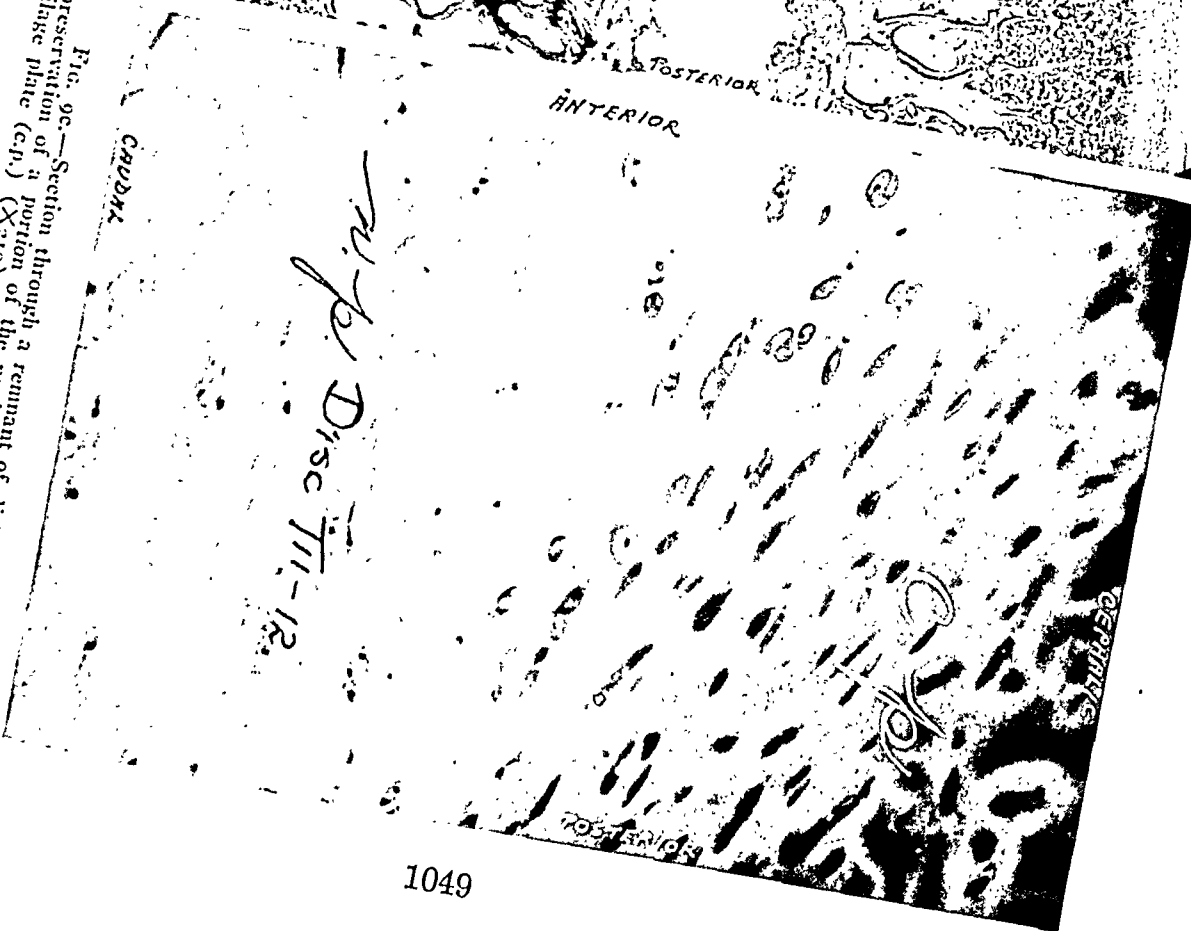


Fig. 9c.—Section through a remnant of disk T 11-12, showing preservation of a portion of the nucleus pulposus (n.p.) and cartilage plate (c.p.) (X10).



Spread of tuberculosis from centrum to centrum through the intervertebral disks has not been noted in our studies. These patients were young children or adolescents and the cartilage plate, a continuation of the epiphyseal rim cartilage, is thicker during the growth years, constituting a more effective barrier to the direct spread of the disease than obtains in the adult spine. Instead, the tuberculous exudate had spread by extension beneath the paravertebral ligament about the periphery of the intervertebral disk from body to body in three cases in which the disease was still active, and posteriorly into the spinal canal in two cases. No area of direct extension through the dura and direct involvement of the spinal cord was noted.

Tubercles in the spongiosa, when present, are of characteristic appearance, with round and epithelioid cells around central necrotic foci, many of which contain giant cells. In some sections, although spongiosa and cortex were converted into tuberculous débris, with necrosis, collapse and partial absorption of the bone, no typical tubercles could be found.

As has been shown in previous communications,^{12, 30} any damage to the cartilage plate, the result of trauma or disease, may permit escape of all or a part of the nucleus pulposus, with reduction in size and loss of contour of the intervertebral disk. This loss of the semifluid nuclear material may explain the narrowing of the disk line occasionally seen in the early roentgenogram in tuberculosis of the spine. Because of the incompressibility of the nucleus pulposus, any change in the shape of the disk must be attended by change in or escape of this nuclear material.

Primary tuberculous invasion of the annulus fibrosus has not been demonstrated but erosion of the disk structure by caseous débris beneath the anterior paravertebral ligament is not uncommon.

In vertebral tuberculosis without secondary pyogenic infection, there is little tendency toward regeneration of bone. Albee¹ and Delchef⁶ have argued that this lack of new bone formation justifies the utilization of the tibial bone graft for a firm spinal arthrodesis.

The neurologic aspect of vertebral tuberculosis includes the formation of epidural or subdural abscesses, with direct or hematogenous spread to the tissues of the central nervous system. The spinal cord may be crushed by collapse of the centra but this is an uncommon occurrence and has not been found in our cases.

The symptom-syndrome described as "Pott's paralegia" may be due to pressure on the cord by posteriorly displaced disk substance, necrotic tuberculous débris or extradural abscess within the spinal canal or to edema of the cord occurring secondary to the regional inflammation.

Tuberculous peritonitis is a rare sequela of vertebral disease, while meningitis is relatively common. Acute miliary tuberculosis has followed the spinal infection. Dissemination of the infection may be from the diseased vertebrae or by invasion of the blood stream (Corret, Michon, and Reny⁵), from the original focus in the lung or lymph nodes. Fossel¹¹ has described a

case of generalized miliary tuberculosis following the erosion of spinal caries into the aorta.

PART II

VERTEBRAL OSTEOMYELITIS

In pyogenic infections of the spine as in vertebral tuberculosis, the primary focus is in the bone and not in the joints. The intervertebral disk is less able

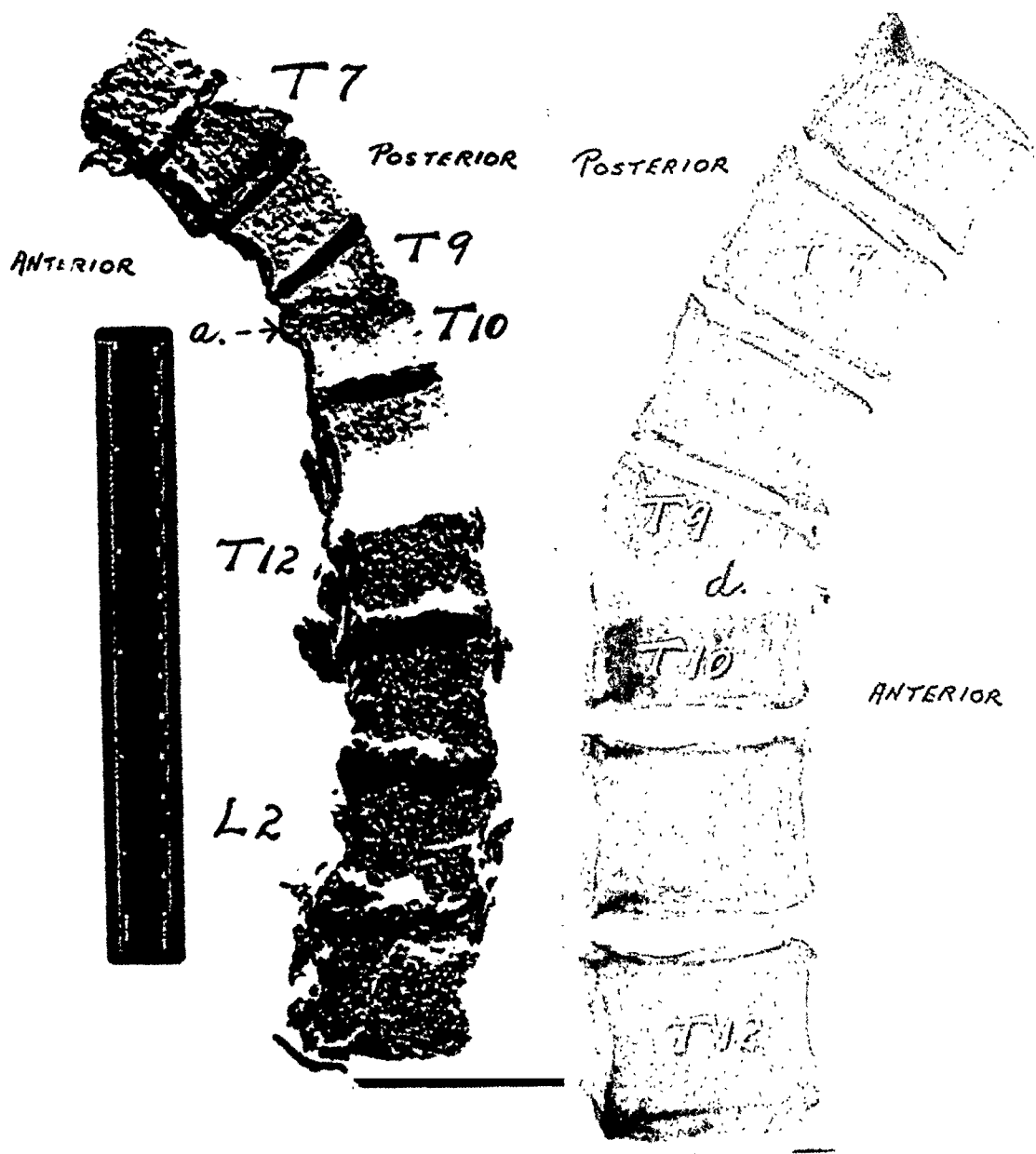


FIG. 10a.—(Case 5) Age 55. Osteomyelitis. Photograph of split section from T 6 to L 3. The bodies of T 10 and especially T 9 are partially collapsed anteriorly. Disk T 9-10 has been disrupted and a portion of it extruded anteriorly (a.). Other bodies and intervertebral disks are intact.

FIG. 10b.—Roentgenogram of split spine section. Irregular absorption of the contiguous halves of T 8 and T 9 produces the wedging described in Fig. 10a. The disk area (d.) has lost its contour and the tissue filling the disk space casts a mottled shadow suggesting beginning ossification.

to survive the attack of pyogenic disease and the following cases showed early roentgenographic evidence of loss of intervertebral space.

Case 5.—F. C. T., male, age 55, was admitted to the University of Chicago Clinics October 4, 1933. The patient gave a history of pain in the lower thoracic spine of eight

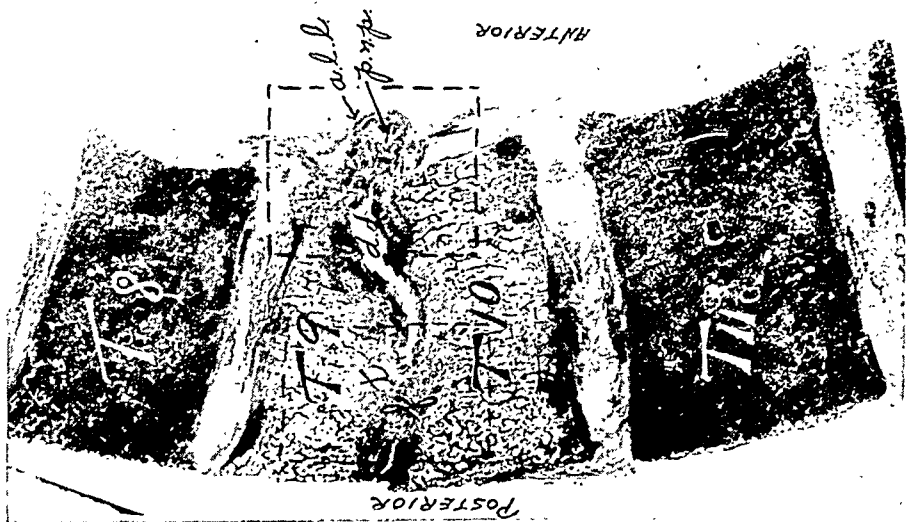


FIG. 11a.—(Case 5) Age 55. Osteomyelitis. Disk T 9-10 has been completely disrupted (d.d.). The necrotic remnants of this disk and a portion of the nucleus pulposus (p.m.p.) have been extruded anteriorly beneath the paravertebral ligament (a.l.l.). New fibrous tissue (f.t.) bridges the posterior portion of the old disk space (X₂).



FIG. 11b.—A higher magnification through the extruded disk debris (p.m.p.) and the intervertebral space (d.d.) of T 9 and T 10. The anterior ligament (a.l.l.) about the extruded disk substance is covered on its inner surface by a pyogenic membrane (p.m.). A small portion of the annulus (a.f.) is present at the osseous margins. The bone trabeculae have been extensively destroyed by direct extension of the infection (X₁₀).



FIG. 11c.—Fibrous tissue (d.f.) extends across the old disk space of T 9-10. New bone trabeculae are present at the disk margins but do not extend across (n.b.). Some devitalized hyaline cartilage (d.c.) may be seen posteriorly at the upper edge of the former disk space (X₁₀).

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weeks' duration. Two weeks before the onset of symptoms, he had been confined to bed with an illness thought to be influenza. Abdominal pain developed and this later localized in the lower dorsal spine.

The lateral roentgenogram showed gross destruction of the intervertebral disk T 9-10 and of the approximating portions of the centra. The condition was diagnosed tuberculosis and a spinal fusion was performed October 23, 1933. The patient had a severe postoperative reaction and died the following day. Necropsy revealed multiple septic foci, including pyelonephritis, infarcts of the spleen and kidneys, and acute generalized peritonitis. A sagittal section of the vertebral bodies from T 6 to L 3 was removed.



FIG. 12a.—(Case 6) Age 17. Osteomyelitis. The bodies of T 11 and T 12 are joined by new bone trabeculae. Disk T 11-12 is represented by two small cartilaginous inclusions (c.c.), and a posteriorly situated abscess cavity (a.c.) is the only remaining focus of pyogenic infection. The defects in the cartilage plates of the disk below are precursors of nucleus pulposus herniations, as described by Schmorl (d.c.p.) (X2).

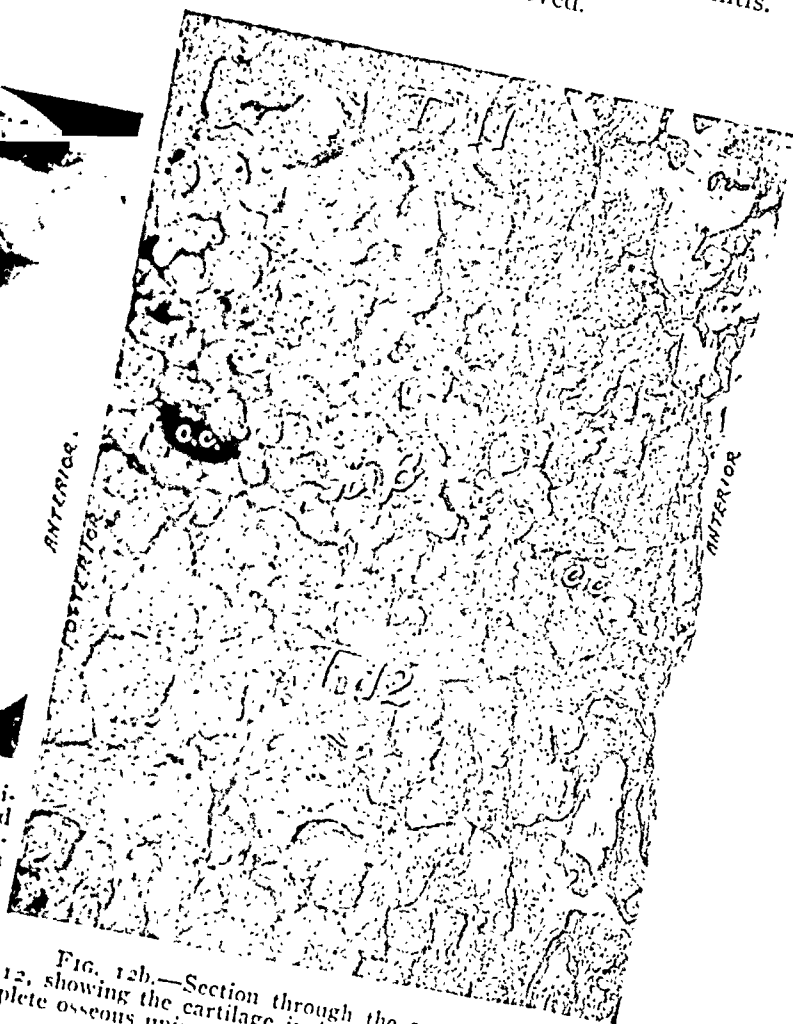


FIG. 12b.—Section through the area of disk T 11-12, showing the cartilage inclusions (c.c.), and the complete osseous union of the two vertebrae (n.b.) (X10).

Pathology.—Vertebral bodies T 9 and 10 are eroded on their contiguous surfaces. The disk between these two vertebrae has been destroyed and replaced by fibrous tissue and exudate which bulges anteriorly into the paravertebral ligament. No gross abscesses or sequestra can be identified.

The roentgenogram of the sectioned spine (Fig. 10b) shows wedging of T 9, partial loss of contour of T 10 and destruction of the disk, with anterior protrusion of a portion of its substance. Adjacent vertebrae are grossly and roentgenologically normal.

Four vertebrae are included in the microscopic sections (Fig. 11). Disk T 9-10 has been almost completely destroyed. Small islands of articular cartilage are present at each end of the old disk space. The posterior half of the annulus has been replaced by granulation tissue containing areas of new bone formation. The anterior half is largely necrotic and contains small collections of fibrin and polymorphonuclear leukocytes. There are small islands of newly formed bone in the cancellous bone bordering the interspace.

COMMENT.—The nature of the onset, short duration, severity of the symptoms, rapid destruction of the disk substance, and the acute bone necrosis shown in the roentgenogram should have established the correct diagnosis of pyogenic osteomyelitis.

Pathologic studies indicate that extension was through the disk with disruption of its structure, but the primary focus of infection could not be definitely established. Greater destruction of T 8 than T 9 might indicate that the former was primarily involved. There was no migrating paravertebral abscess.

Case 6.—C. H., male, age 14, was admitted to the University of Chicago Clinics November 20, 1931, with a diagnosis of pyogenic arthritis of the right hip and multiple osteomyelitis.

The onset was acute, but there were no symptoms referable to the spine until three years later when a minimal deformity in the lower dorsal spine was noted. A large retroperitoneal abscess was diagnosed and drained July 17, 1934. A roentgenogram on July 19, 1934, showed partial destruction of the centra of T 11 and T 12, with complete obliteration of the disk space.

Death occurred August 7, 1934, from generalized amyloidosis. A section of the spine removed at autopsy included vertebrae T 9 to L 2.

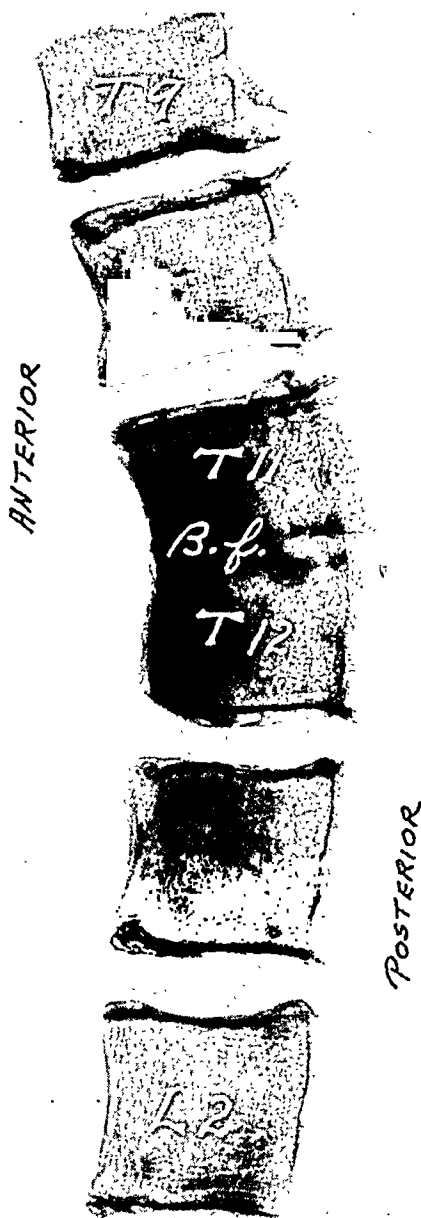
Pathology.—The split spine section shows the complete disruption of the intervertebral disk between T 11 and 12 with osseous union of the two centra. The microscopic section of disk T 12—L 1 shows a small break in either cortex with beginning extension of the adjacent fibrocartilaginous tissue into the vertebral bodies (Fig. 12).

Two cartilage islands, surrounded by bone, are still present at the site of disk T 11—12, and posteriorly at this level there is a small abscess. The bone of the fused region and for a great distance away contains marrow made up of granulations and fibrous tissue.

FIG. 13.—(Case 6) Age 17. Osteomyelitis. Roentgenogram of split section of vertebral bodies. There has been only a small loss of substance of the bodies of T 11 and T 12, but complete loss of the intervertebral space. Bony fusion (b.f.) is present between these two vertebrae. The other disks and vertebral bodies are intact.

13) shows the osseous fusion between the centra of T 11 and T 12, with loss of intervening disk space, and moderate wedging of the shadows of these vertebrae anteriorly, producing mild kyphosis.

COMMENT.—This case illustrates destruction and osseous replacement of intervertebral disks in pyogenic spondylitis. New bone formation, common in the healing of pyogenic osteomyelitis, is shown.



DISCUSSION: PART II.—Pyogenic vertebral osteomyelitis is commonly a hematogenous infection, secondary to a focus of infection elsewhere in the body. According to Volkmann,³³ the initial focus of pyogenic vertebral osteomyelitis is in the neural arch more frequently than in the vertebral body. In his series of 70 cases of pyogenic infections of the spine, 59 per cent showed involvement of the arch or its processes, 34 per cent involvement of the body, while in the remaining 7 per cent both were affected. This analysis was based partly on autopsy and partly on clinical and roentgenologic studies of his own cases and those reported by others. Kulowski^{19, 20} has recently reported an excellent clinical study of pyogenic osteomyelitis of the spine. His statement that some of his patients showed primary hematogenous intervertebral disk infections cannot be reconciled with the anatomic fact that this structure is avascular.

In contrast to tuberculous spondylitis, there is a rapid and early involvement of the intervertebral disk in pyogenic infection of the vertebrae. The cartilage plate is rapidly destroyed by the proteolytic enzymes formed in pyogenic exudate and the nuclear substance is extruded. The fibrous annulus also undergoes dissolution. This is comparable to the destruction of articular cartilage of joints of the extremities as it is known to occur in severe pyogenic arthritis.

When the acute infection subsides there is regeneration of bone, and ankylosis of vertebral bodies occurs much more commonly and more rapidly than in cases of tuberculosis of the spine. Persisting sequestra are uncommon, as spongy dead bone is quickly absorbed, but when present may be found within the spongiosa of the vertebral body or in the compacta of the arch. Volkmann reports more frequent sequestration of the spinous process when this part of the arch is involved.

PART III

VERTEBRAL TUBERCULOSIS COMPLICATED BY PYOGENIC INFECTION

Secondary pyogenic infection is a frequent complication of tuberculosis of the skeleton when a cold abscess is incised or opens spontaneously to the surfaces of the body. This combination of pyogenic and tuberculous infection decreases the patient's chances of recovery. Sinuses of this type characteristically do not heal, and generalized amyloid disease and death may result from the infection and the continued loss of body proteins in the exudate. The pathologic changes that occur in the spine from this mixed infection may be typical of either tuberculosis or of pyogenic osteomyelitis, or a combination of the two.

Case 7.—F. E., male, age 17, was admitted to the University of Chicago Clinics July 8, 1931. A diagnosis of tuberculosis of the thoracolumbar spine had been made in 1923. Drainage from a lumbar abscess had been present since 1926.

A spinal fusion was performed July 20, 1931. The immediate postoperative course was satisfactory and there was clinical improvement for a period of almost two years. The sinuses did not heal, although postoperative roentgenographic studies indicated osseous re-

pair in the spine. Amyloid disease was present, renal insufficiency became more marked and death occurred April 16, 1934, at the age of 19 years, 10 months.

The diseased section of the thoracolumbar spine was removed at autopsy.

Pathology.—The split spine section shows a marked dorsolumbar kyphos with complete destruction of the bodies of T 10 to L 1 with the exception of the posterior part of T 10 (Fig. 14a). The bodies of L 2 and L 3 show partial osseous union with loss of disk substance. The presence of necrotic material, surrounded by fibrous tissue, beneath the interior ligament at the level of the kyphos indicates the mode of spread of the infection. The intervertebral space at the apex of the kyphos is occupied by a small abscess posteriorly

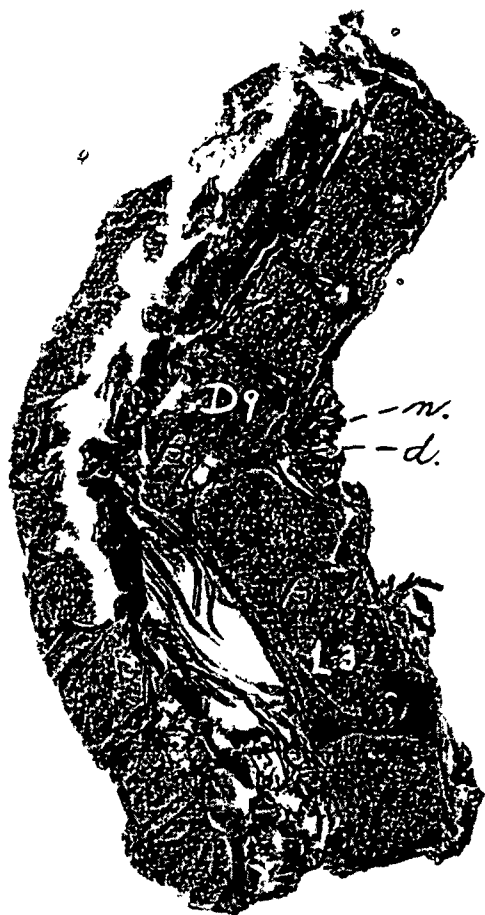


FIG. 14a.—(Case 7) Age 19. Tuberculosis and Secondary Pyogenic Infection. Photograph of split section of lower thoracic and lumbar spine. The bodies of T 10 to L 1 are destroyed. At the level of the kyphos (k.), a portion of the tenth thoracic body (b.) projects into the spinal canal. Bony fusion (b.f.) has occurred between the bodies of L 2 and L 3. The disk (d.) is preserved in its anterior half, while lower thoracic disks are completely disrupted. Necrotic debris (n.) is present beneath the anterior ligament.

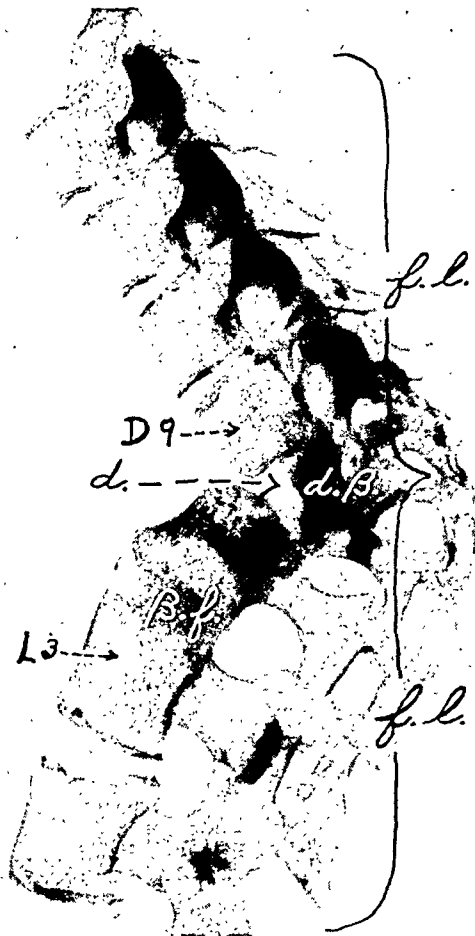


FIG. 14b.—Roentgenogram of the previous section. Four centra (d.b.) at the thoracolumbar junction have been largely destroyed, leaving an irregular intervening space (d.). The second and third lumbar vertebrae show intimate bony fusion (b.f.). The surgical union of the laminae (f.l.) splints the diseased segment of the spine.

and by fibrous tissue anteriorly. Immediately in front of it there is another abscess pocket surrounded by thick fibrous tissue. The notch anteriorly between the partly fused bodies of L 2 and 3 is filled by fibrous tissue. The arches posteriorly are joined by a strong plate of bone in which the tibial bone grafts are firmly united to, and blended with, the laminae. The meninges and cord are free.

A roentgenographic study of the section (Fig. 14b) shows the extensive destruction of the bodies of the three lower thoracic and the first lumbar vertebrae, with bony fusion

of L 2 and L 3. There is osseous fusion of the laminae from the eighth thoracic to the third lumbar.

The microscopic section includes portions of seven vertebrae (Fig. 15). Four bodies and intervertebral disks have been destroyed by the infection. The disk between D 9 and D 10 is represented by three isolated cartilage islands and a remnant of fibrous tissue.

At the level of the kyphos the three abscess cavities are lined with a pyogenic membrane and filled with necrotic debris and the walls are heavily infiltrated with lymphocytes (Fig. 15a and b). Islands of epithelioid cells are also present. The marrow of the vertebrae bordering this region has been in part replaced by fibrous tissue, which is infiltrated with round cells. The surrounding marrow is rich in hematopoietic cells. New bone has formed across the disk between D 2 and D 3 (Fig. 15c). Tuberculous granulation tissue containing epithelioid and giant cells is present in the anterior portion of the gap at the site of the kyphos.

COMMENT.—This case illustrates the pathologic changes brought about by both tuberculosis and osteomyelitis of the spine. These include extensive destruction of the fibrous and cartilaginous disks as well as of bone, and new bone formation and are as typical of pyogenic as of tuberculous infection.

Case 8.—W. P., male, age 8, was admitted to the University of Chicago Clinics February 18, 1931. This patient was first seen at the Home for Destitute Crippled Children in July, 1926, at which time a diagnosis of tuberculosis of the spine was made. In April, 1929, a psoas abscess and sinus developed which had continued to drain. In December, 1930, a diagnosis of amyloidosis and renal insufficiency was made.

September 17, 1931, the spine was fused with a rib graft. The patient recovered from the operation and for a few months there was improvement. Sinuses continued to drain, however, and approximately one year following the operation he died of amyloid nephrosis and uremia.

The diseased segment of the spine, from T 6 to L 5, was obtained at autopsy.

Pathology.—The sagittal section (Fig. 16a) shows osseous fusion of laminae and posterior spinous processes. The centra are reduced in their anteroposterior diameters. There is a kyphos in the lower thoracic spine. Collapse of the vertebral bodies from T 8 to T 11 has occurred but there is preservation of a portion of each intervertebral disk.

The centrum of T 9 is displaced backward so that it encroaches upon the spinal canal. The dura has not been invaded but a mass of debris can be seen extending downward anteriorly in the extradural space to the level of L 5. There is evidence of anterior invasion of the vertebral bodies from T 6 to L 4.

The roentgenogram of the split spine section (Fig. 16b) shows the previously described loss of substance of the centra of T 8, 9, 10, and 11, with partial preservation of the intervertebral disk spaces. The centra of L 1 and L 2 are firmly fused together and there is less complete bone union between L 4 and L 5.

The microscopic section includes six of the vertebral bodies (Fig. 17). The centra are reduced in size but do not show the usual wedging characteristic of extensive tuberculous invasion. The intervertebral disks show varying degrees of destruction and in places are bridged by new bone.

Some of the marrow is fibrous, but much of it is richly vascular and hematopoietic. Clumps of round cells and small abscess cavities are present in several of the centra. An occasional giant cell is visible in the pyogenic membrane lining the abscess cavities and a few tubercles, without caseous necrosis, can be identified.

COMMENT.—This case is complicated by the presence of the dual infection and presents features common to both tuberculosis and osteomyelitis. The loss of disk substance and bony coalescence in the lower thoracic and lumbar



Fig. 15a.—(Case 7) Age 19. Tuberculosis and Pyogenic Infection. Seven vertebrae of the thoracolumbar spine are included in the section. Only two disks (iv.d.) at each end of the section have been preserved. Remnants of other disks are represented by small islands of cartilage (c.c.). New bone trabeculae unite the vertebrae. A large abscess cavity (a.c.) is present at the level of the kyphos and two similar cavities may be seen beneath the anterior longitudinal ligament (a.l.l.). Invasion of an old disk space may be noted (a.) (X2).



Fig. 15b.—Section through the disk fragments at the level of the kyphos, showing cartilage islands (c.c.), abscess cavities (a.c.-a.c.b.) and the osseous fusion (n.b.) between adjacent centra (X10). Tuberculous granulation tissue containing epithelioid and giant cells is present in the gap at this level.

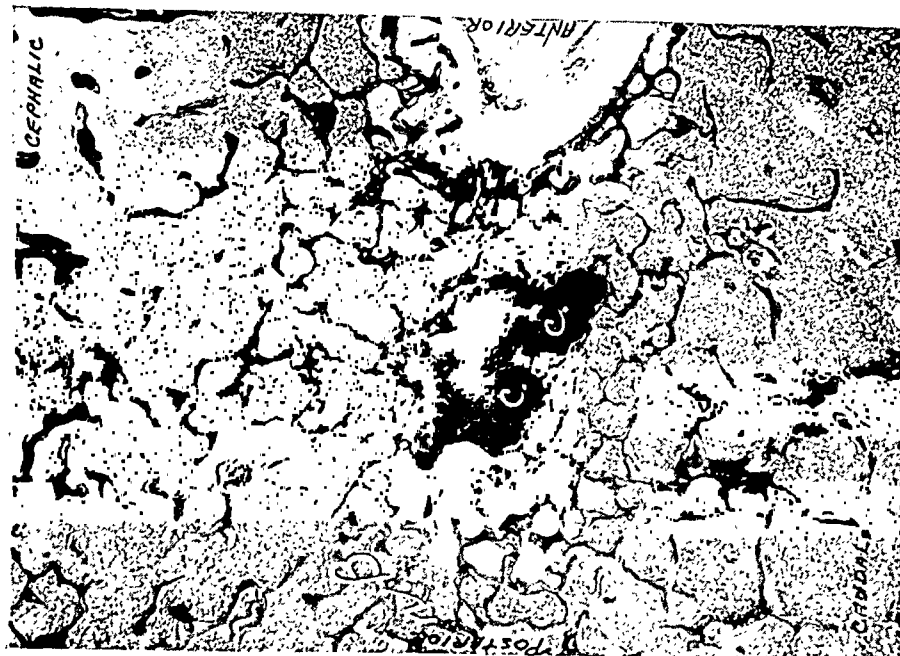


Fig. 15c.—A disrupted intervertebral disk at the distal part of the section. The only remnants of disk structure at this level are two small cartilaginous masses (c.c.) which have lost most of their cells and are partially calcified. Bone trabeculae (n.b.) have formed across the old intervertebral disk space (X10).

DISEASES OF THE SPINE

spine are more typical of pyogenic spondylitis. Preservation of considerable portions of the fibrocartilage of some disks where adjacent vertebrae have been markedly narrowed in their anteroposterior diameters, is more typical of an uncomplicated tuberculous spondylitis and indicates that the pyogenic infection was not extensive.

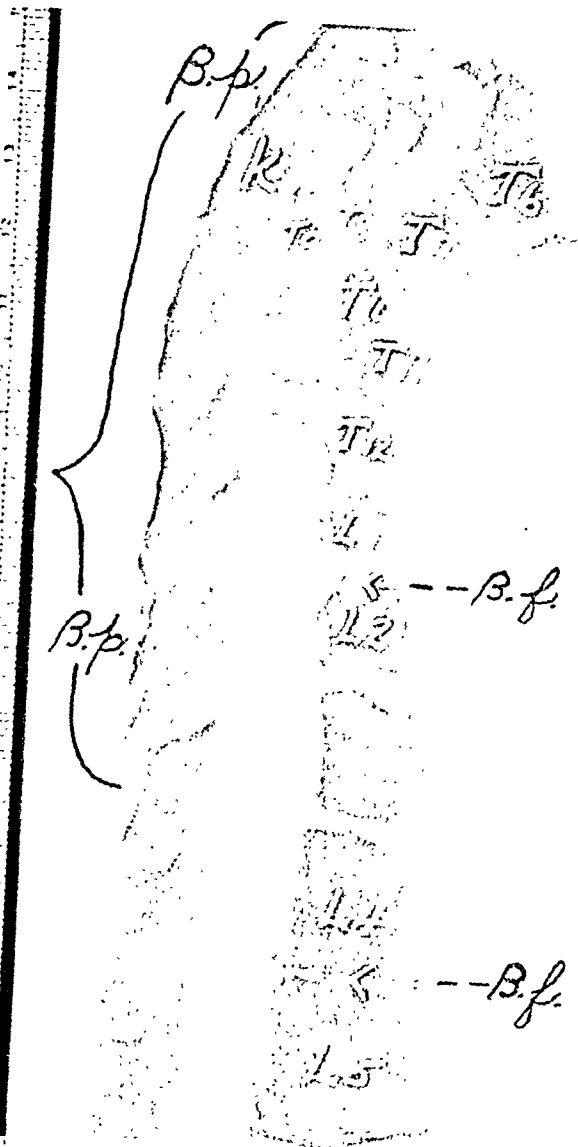
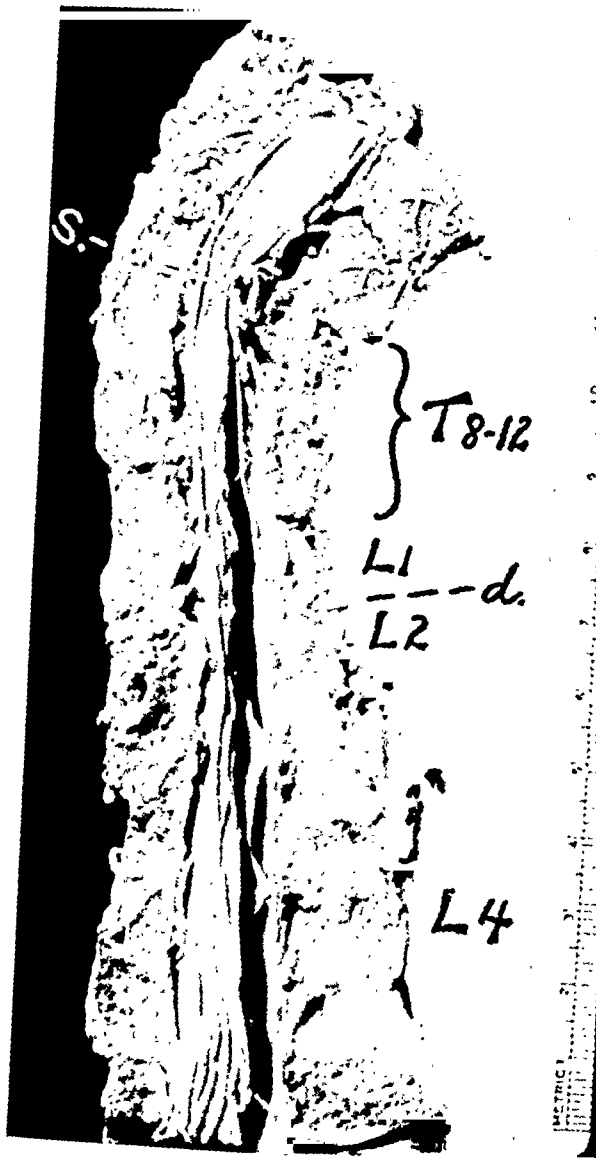


FIG. 16a.—(Case 8) Age 9. Tuberculosis and Pyogenic Infection. Photograph of the split section from T 6 to L 5. The kyphos (k.) is at the level of T 8. The collapsed mass of T 9 has been displaced backwards and encroaches upon the spinal canal (s.). The disk (d.) between L 1 and L 2 has been completely disrupted and the bodies have united.

FIG. 16b. Roentgenogram of split section. The bodies of T 8, 9 and 10 have been destroyed and form the apex of the kyphos (k.). Bony fusion (b.f.) is present between the centra of L 1 and 2 and L 4 and 5. The laminae from T 6 to L 2 are fused into a solid plate of bone (b.p.).

Case 9.—W. C., male, age 5. A diagnosis of tuberculosis of the thoracic spine was made in March, 1931.

There was moderate kyphosis and roentgenograms revealed a destructive lesion of the fourth, fifth and sixth thoracic vertebrae and a paravertebral abscess.

A two stage spinal fusion was performed on August 3 and August 19, 1931. The post-operative course was satisfactory and there was clinical and roentgenologic evidence of healing of the diseased spine. November 16, 1934, he was readmitted to the Clinics because of persistent high temperature of several weeks' duration. A paravertebral abscess was drained on November 21, 1934, with temporary relief of symptoms.



Fig. 17b.—The posterior end of a disrupted intervertebral disk (d.iv.d.) has been largely replaced by new bone trabeculae (n.b.). The posterior ligament (p.p.l.p.) has been lifted from the centra by an abscess (a.c.) the walls of which are infiltrated with round cells and an occasional tubercle.



Fig. 17c.—Remnants of the hyaline cartilage and annulus of two disks (d.iv.d.). Newly formed bone (n.b.) unites the two vertebrae (X10).

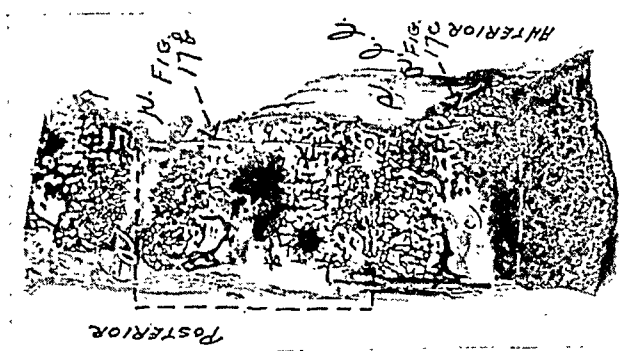


Fig. 17a.—(Case 8.) Age 9. Tuberculosis and Pyogenic Infection. This section includes six of the lower thoracic vertebrae. In only three areas (a.b.c.) may any disk structure be identified. Newly formed osseous tissue (n.b.) is growing through the anterior portion of the lower disk. The anterior ligament (a.l.l.) has been raised from the vertebral bodies by the migration of exudate and debris. Note the anterior invasion of a proximal disk (r.) and of a centrum (s.) (X2).

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Posterior mediastinitis developed and on January 14, 1935, drainage was established by incision through the eighth thoracic interspace. *Streptococcus hemolyticus* was grown in culture, and death occurred January 16, 1935. The abscess cavity extended along the front of the bodies of almost the entire thoracic spine. A segment of the spine from D 2 to D 12 was obtained at necropsy.

Pathology.—The bodies of T 4, 5 and 6 are triangularized and wedged, but show preservation of the anterior portion of the intervertebral disks (Fig. 18a). Only a small portion of the body of T 5 can be identified. Exudate and detritus elevate both the anterior and the posterior paravertebral ligaments, with surface invasion of the centra from the level of T 6 to T 11. The annulus of disk T 6-7 has been eroded from its dorsal aspect. The nucleus of disk T 7-8 has been destroyed. Disk T 8-9 has also been invaded. On the under surface of disk T 9-10, a part of the cartilage plate has been eroded by extension of a metaphyseal focus but the nucleus has not yet been extruded.

A roentgenogram of the split spine sections (Fig. 18b) shows fusion of the remnants of the bodies of T 4 and T 5. The erosion of the cortex of the superior and inferior surfaces of T 10 can also be recognized. There has been erosion of the posterior portion of T 8 and a similar change is noted on the distal margin of T 10 and on the anterior surface of T 11. The bone graft has been involved by the infection in its lower portion and presents a moth-eaten, necrotic appearance.

T 3 to a portion of T 9 is included in the first microscopic section (Fig. 19a). The remnant of T 5 is not shown. Intervertebral disks T 3-4 and T 6-7 are well preserved. The cartilage plates of disk T 8-9 have been eroded and much of the disk substance replaced by fibrous tissue and small abscess cavities. The contour of disk T 7-8 is preserved but there is invasion by newly formed bone trabeculae at the dorsal margin and a cyst-like area is shown at about the site of the nucleus pulposus. This area is lined with fibrous tissue, but the bone fragments and debris which fill it are artifacts from the sawdust made in splitting the spine (Fig. 19c).

The spongiosa of T 4 and T 6 is composed partly of old and partly of new trabeculae (Fig. 19b). Some of the marrow has been replaced by fibrous tissue in which scattered round cells, fibroblasts and small blood vessels may be identified. Isolated tubercles are visible in the centra of T 3, 4 and 6. The posterior paravertebral ligament has been lifted from the centra by the migration of an abscess which is lined by a pyogenic membrane.

Microscopic section (Fig. 19d) includes a portion of T 9 to T 12. A small abscess cavity lined with a pyogenic membrane is visible at the lower posterior portion of T 10. The cartilage is thinned beneath this cavity and the cortical bone has been absorbed. Another abscess is visible at this level, within the substance of the posterior ligament (Fig. 19e). The contour of all of the intervertebral disks at these lower levels has been preserved. None of the nuclei has been extruded or destroyed. The walls of the abscess cavities are infiltrated with round cells and polymorphonuclear leukocytes but no tubercles could be found in this section.

COMMENT.—Clinically, this case is one of acute vertebral tuberculosis which showed improvement following internal splinting and bed rest. Secondary infection from hemolytic streptococci led to abscess formation, mediastinitis and death. Preservation of intervertebral disks is marked when compared with the amount of osseous destruction. The pathologic and roentgenologic picture indicates that the pyogenic infection was acute and of short duration.

DISCUSSION.—The current report by Finder⁹ of extensive studies of the pathologic changes in the healing process in tuberculous spondylitis in a single adult patient has been reviewed. The findings which are shown in the published roentgenograms and photomicrographs of this case are quite similar

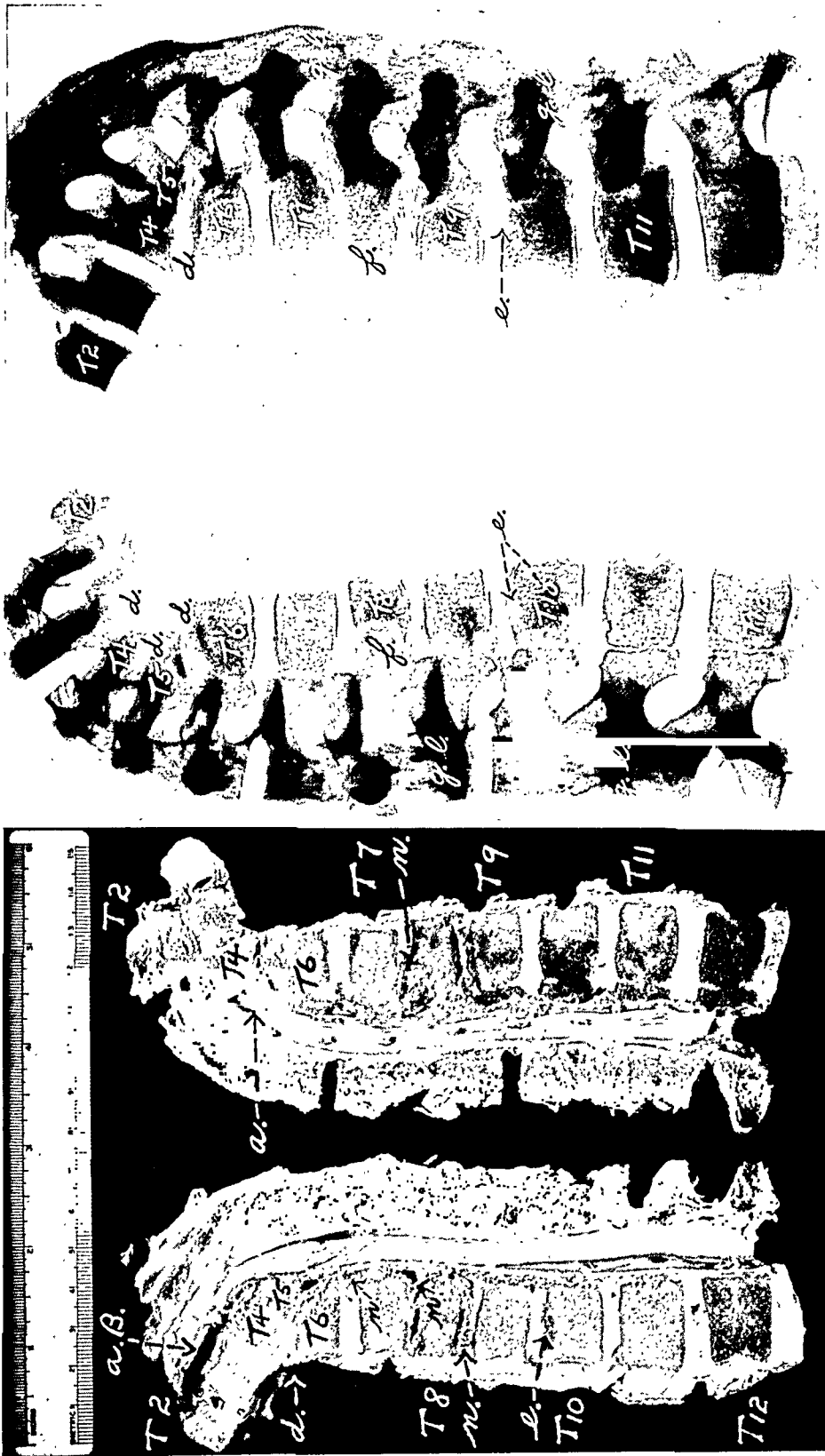


FIG. 18a.—(Case 9.) Age 9. Tuberculosis and Pyogenic Infection. Photograph of split spine section from T2 to T12. The bodies of T4, 5 and 6 are collapsed and wedged. The anterior portion of disk T5-6 (d.) is preserved, but its posterior portion is represented only by necrotic debris surrounding an abscess cavity (a.). A similar cavity (a.b.) is visible on the dorsal aspect of the bodies of T2 and 3. Three of the lower disks show invasion (n.) The cartilage plate on the superior surface of T10 is undergoing erosion (e.) from a sub-jacent metaphyseal focus.

FIG. 18b.—Roentgenogram of split spine section. The bodies of T4, 5 and 6 are wedged and the intervening disks (d.) partially destroyed. There is beginning erosion (e.) of the upper surface of T10 and more extensive absorption and fragmentation of T8 (f.) The lower part of the tibial bone graft and corresponding lamina show extensive necrosis (g.l.).

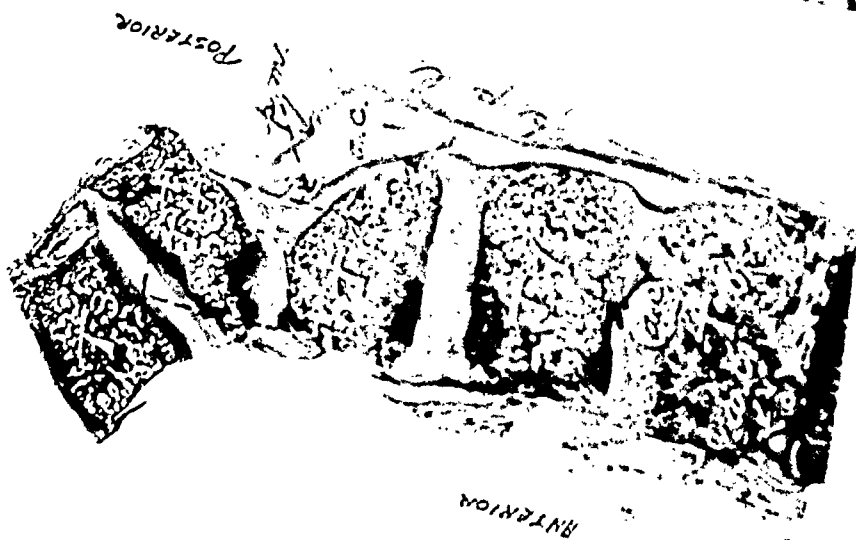


Fig. 10a.—(Case of Age 3 years) Tuberculosis and Pyogenic Infection to the upper fourth of the section. The center of the infection was largely necrotic and showed loss of structure. Several abscess cavities could be seen in the section, some within the anterior level of the hyaline, some in the pyogenic membrane (p.m.). The posterior vertebral bodies have been lifted from the vertebral bodies by exuberant and dense



Fig. 10b.—This section is at the level of the anterior vertebral body. The infection is at the level of the body. The center of the infection is largely necrotic and showed loss of structure. Several abscess cavities could be seen in the section, some within the anterior level of the hyaline, some in the pyogenic membrane (p.m.). The posterior vertebral bodies have been lifted from the vertebral bodies by exuberant and dense



Fig. 10c.—The cystic cavity in disk T-8 (c) is lined with a thin membrane (p.m.) and contains spicules of bone and dense tissue from surrounding the spine. Newly formed bone trabeculae (n.b.) are shown invading the disk substance (s.m.).

to those of Case 7 of our series. In both cases there were multiple sinuses with secondary pyogenic infection, fusion of remnants of vertebral bodies and sclerosis of bone (less marked in our case). Active tuberculosis and abscesses were present. These findings are not those of healing uncomplicated tuberculosis, but can best be explained on the basis of the dual infection and are more typical of chronic osteomyelitis than of tuberculosis.

Tuberculosis of the spine commonly begins as a metaphyseal focus, and

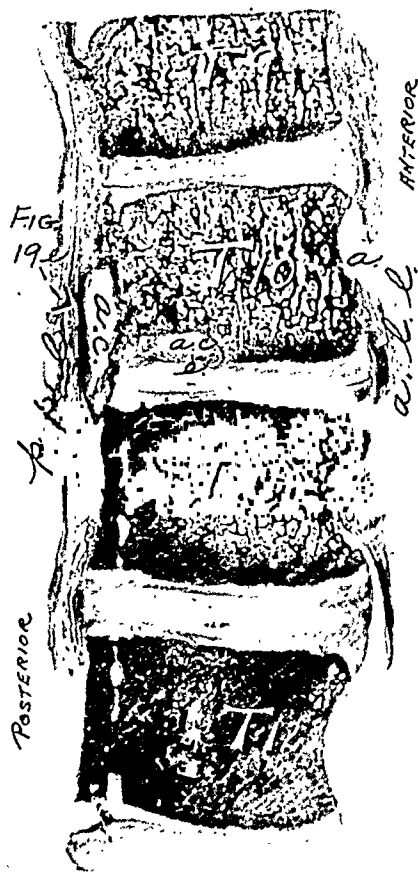


FIG. 19d.—(Case 9) Age 9. Tuberculosis and Pyogenic Infection. The section includes T₁₀, 11 and 12, with a portion of T₉. Abscess cavities are visible at the level of disk T₁₀-11, within the cancellous bone and in the posterior ligament (p.p.l.). The cartilage plate adjacent to the abscess cavity has been eroded (e). Anterior invasion of the centra of T₁₀ and 11 may be noted at (a.) and (b.) (X2).

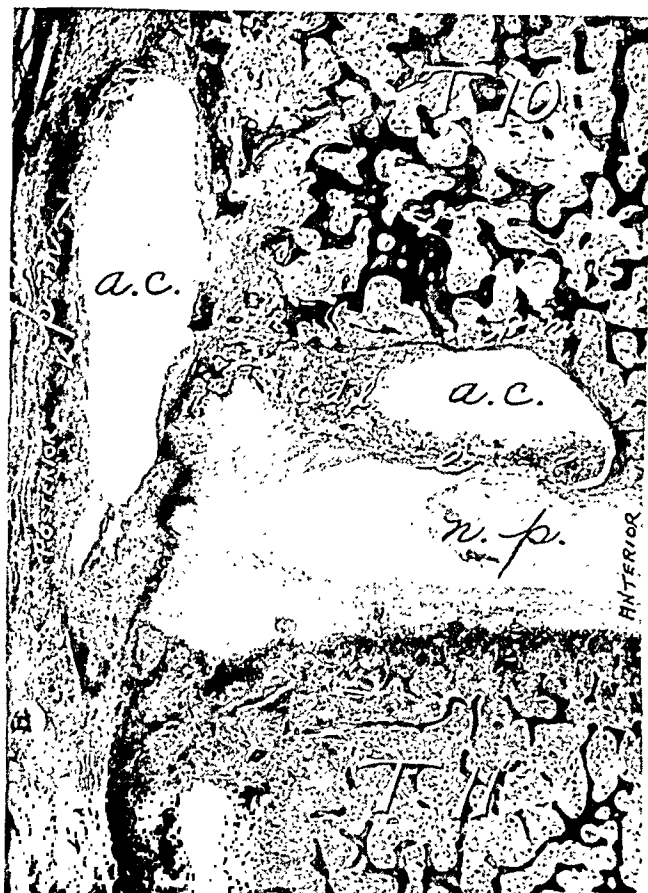


FIG. 19e.—Section through the abscess cavities at the level of disk T₁₀-11. Both cavities (a.c.) are lined with a pyogenic membrane (p.m.) and partially filled with cellular debris and leukocytes (c.d.l.). The abscess at the disk margin has extended most of the way through the cartilage plate. The nucleus pulposus (n.p.) is still intact. This shows well the invasion of the bone first, followed by extension into the disk. No typical tubercles could be found in this section (X10).

the vertebral appendages are rarely involved. It is primarily a bone destroying infection and in the active stages of the disease there is little tendency toward bone repair which can be found either in the roentgenologic or pathologic specimen. The intervertebral disk, on the other hand, resists the tuberculous infection so that, as shown in some of the cases presented, the specimen may show extensive loss of several vertebral bodies with preservation of some of the cartilage and annulus of the corresponding intervertebral disks. The narrowing of the disk and the apparent thinning of disk space which

may be seen in the roentgenogram in comparatively early cases of tuberculosis of the spine may result from extrusion of the nucleus pulposus into disease softened osseous or ligamentous tissue.

Pyogenic infection is frequently primary in the arch or vertebral appendages. Early and complete destruction of the intervertebral disks is common. In contrast to tuberculosis of the spine, bone regeneration and fusion of vertebral bodies may be quite marked both in the roentgenologic and in the pathologic specimen. This rapid destruction of the intervertebral disk is accomplished by the proteolytic enzymes produced by the polymorphonuclear leukocytes in pyogenic exudates.

Tuberculosis of the spine spreads by extension of abscesses under the anterior longitudinal ligaments with surface invasion of the vertebral bodies anteriorly. The fibrous annulus of intervertebral disks that are in direct contact with the tuberculous abscesses show relatively little absorption while they are promptly destroyed by pyogenic exudate. In some cases there is hematogenous involvement of vertebrae at two or more levels.

Pyogenic infection may spread by direct extension through an intervertebral disk from vertebral body to vertebral body, but this manner of spread of vertebral tuberculosis has not been found in our studies.

Pressure on the spinal cord and the slow onset of spastic paralysis is more commonly caused by tuberculous spondylitis. Meningitis more commonly follows pyogenic osteomyelitis. Tuberculosis characteristically produces a slowly progressive deformity of the spine characterized first by a small knuckle or gibbus and later a kyphos which may result in the development of a "hunchback" dwarf. Pyogenic osteomyelitis does not produce extensive collapse of vertebral bodies and marked kyphosis.

Secondary infection of a tuberculous psoas abscess may produce pathologic and roentgenologic changes which are characteristic of osteomyelitis as well as the initial tuberculous infection.

Among infectious diseases, other than those caused by the more common pyogenic organisms, which may produce changes roentgenologically similar to those of spinal tuberculosis, are undulant fever, syphilis, and osteo-arthritis. Undulant fever is caused by an organism of one of the *Brucella* subgroups. Kulowski and Vinke¹⁰ reported a case with involvement of the lumbar spine in which manual contact with suspicious infected cattle was the source of contamination. Archer² reported a case which was first diagnosed "Pott's disease." Other clinical reports of Malta fever spondylitis have been made, but no necropsy studies of human cases have been found in the literature (Guibal and Mas¹²). The disease is common in cattle and swine and results in abscess of the intervertebral body and the disk (Feldman and Olson⁸). Extension appears to be through the substance of the disk to invade the adjacent vertebrae.

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GIANT CELL TUMORS OF THE JAWS

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THE giant cell tumor is a comparatively uncommon lesion, and such a growth occurring in the mandible or maxilla is decidedly rare. The true nature of the tumor and its ultimate prognosis have occasioned wide variation of opinion during the past few years. Although giant cell epulis presents an histologic structure closely simulating that of the central giant cell tumor, the present discussion is concerned only with the latter.

In 1854 Sir James Paget⁹ credited Lebert as being the first to describe the giant cell tumor. However, the history of the lesion really dates from the studies carried out by Nélaton.²¹ He pointed out vividly the benignity of the neoplasm. The term "epulis" was coined by Virchow,¹¹ and unfortunately this poorly descriptive term has been handed down and is still in use today. The usage should be abandoned in favor of a terminology describing the nature, rather than the location, of the neoplasm. In 1837 Warren, of Boston, described benign and malignant forms of vascular erectile tumors of the maxilla, and in this group were probably included central giant cell tumors of the jaw. In the earlier surgical literature the term sarcoma was applied in designating the neoplasm, despite the work and careful observations of Nélaton. In 1910 the benign nature of the tumor was again emphasized by Bloodgood.⁴ At that time he reported 18 cases, all of whom were still alive and well.

Unfortunately, as was the case with most bone tumors prior to the work of the Committee of the College of Surgeons for the Registry of Bone Tumors, numerous terms have been employed to designate this lesion. Nélaton knew it as *tumeur à myéloplaxes*. The term myeloid sarcoma was used almost universally from 1870 until 1910. The contradictory terminology of benign giant cell sarcoma gradually crept into common usage. The Committee for the Registry of Bone Tumors omitted giant cell sarcomata from its accepted nomenclature. As early as 1912 Bloodgood⁵ designated this lesion as giant cell tumor, and this continues to be the accepted terminology.

The etiology of the so called giant cell tumor is still open to question. In general there are two prevailing opinions. The first would explain the lesion on the basis of an inflammatory reaction, whereas the second considers it as a true tumor. Barrie³ considers it a hemorrhagic osteomyelitis, and the pathologic picture as a regenerative granulation process whose end effort is the restoration of areas already destroyed by some injurious factor,

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the etiologic agent responsible not having been ascertained as yet. Others would explain the causative agent on the basis of trauma. Whatever the opinion of a given investigator may be as regards the etiology of bone tumors, it cannot be denied that in at least some cases trauma would seem to play a part. Kolodny¹⁹ believed that the effects of trauma, the regeneration and repair of tissues, the separation and isolation of cell complexes, hemorrhage with consequent absorption and encapsulation and the necrosis of tissue are all likely to play a part in the etiology of mesoblastic tumors, when brought together with certain predisposing factors. He believed it is probable that when a neoplasm makes its appearance immediately subsequent to trauma it is likely that the traumatizing agent merely accentuated the rapidity of the tumor growth. In the series reported by Simmons²⁴ a history of trauma was elicited in a high percentage of cases. Geschickter and Copeland¹³ have elaborated a theory as regards the origin of giant cell tumor of bone which deserves special consideration. They considered it to be the end-result of an imbalance of two normal repair processes: an unusual increase in osteoclastic proliferation, and a diminution or a suspension of new bone formation in an injured cortex. The abnormal osteoclastic proliferation may occur as a phase in the histogenesis of intracartilaginous bone. In support of this hypothesis they contended that benign giant cell tumors develop at the sites where bone is formed from cartilage. The reasons given for the site of predilection for giant cell tumors at the epiphyses is the age of the patient, the common site of injury, the rate and extent of cartilaginous ossification at the end of the bone, and the nature of the blood supply. They contended that in the skull giant cell tumors occur only at sites where the bone is derived from cartilage, and does not form in membranous bones. Before accepting this theory the question should be raised relative to the infrequency for such lesions to arise about the seat of fracture, and about chronic bone infections, in which both phases of bone repair are prominent. Secondly, although the cartilaginous and membranous components of the mandible are ossified during the first year of life, the late appearance of a giant cell tumor of the mandible might be explained as being associated with the osteoclysis incident to shedding of the deciduous teeth. The author questions whether such a lesion would be centrally located, or would not tend to be of the so called epulis type. Kolodny¹⁹ stated that although opinion is not yet definitely settled as to whether the lesion is a true blastoma, or merely an inflammatory process, the trend of opinion in recent years has inclined to the inflammatory theory. On the contrary, Stone and Ewing²⁶ have stated that the more aggressive and destructive cases are certainly neoplastic in character.

Giant cell tumors are of relatively infrequent occurrence. Exclusive of epulis arising from the alveolar borders of the jaws, the records of the surgical pathologic laboratory at Johns Hopkins Hospital over a period of 35 years showed 20 cases of giant cell tumor involving the jaws: six occurred in the maxilla and 14 in the mandible. In the Mayo Clinic series of 84 cases of giant cell tumor listed as to location, nine occurred in the maxilla

and seven in the mandible. Kolodny estimated that the relative frequency of this neoplasm to primary malignant bone tumor is one to two. It is generally agreed that giant cell tumor is a lesion of early adult life. Simmons²⁴ has given the decade of most common frequency as 20 to 30 years, and Geschickter and Copeland¹⁵ estimated that 40 per cent of the cases occur in the third decade. Kolodny¹⁹ found them to occur most commonly between 15 and 25. It is probable that giant cell tumors of the jaws tend to occur at a little earlier age than similar neoplasms of the extremities. Pfahler and Parry²³ thought that the mandible is one of the most common sites of this lesion.

There does not appear to be any special sex predilection. Simmons thought the neoplasms occur with slightly greater frequency in the female.

There are few symptoms produced by the presence of a giant cell tumor. The usual sequence given by Geschickter and Copeland¹⁵ is: trauma, pain, tumor and fracture—all within two to 14 months. Kolodny,¹⁹ on the other hand, considered the giant cell tumor to be of slow growth and of long duration. Pain is not a prominent feature of the condition. Holland¹⁷ has spoken of rheumatic like pain during the development of the growth. Pathologic fracture is often the first symptom of the disease. In the jaws the tumor develops centrally and expands the cortical bone so that deformity can be detected relatively early. The expanded cortical shell often crepitates under the examining finger. The mucous membrane overlying this expanded shell is often dark red, or even purple in color. Tenderness on palpation is either slight or absent. The deformity is often pronounced and exhibits itself as a smoothly rounded mass, the junction of the expanded cortical bone with the normal bone of the jaw being smooth rather than sharply abrupt, as might be suggested by the roentgenograms.

The roentgenographic appearance of the giant cell tumor is characteristic. There is a bulky, roughly spherical or ovoid shadow, the margins of which are fairly definitely demarcated. The shadow is not smoothly circular in outline, but here and there presents small lobulations. There are incomplete trabeculae at the periphery of the tumor. There is no periosteal reaction, and the cortex and the periosteum beyond the tumor appear to be normal. The periosteum is never separated from the uninvolved bone, so that there is no so called reactive triangle. Sometimes the cortex has actually been eroded by the tumor. Kirklin and Moore¹⁸ have expressed the opinion that there is a tendency for the tumor to break down the trabeculae and to form a conglomerate mass. They described a second roentgenographic type in which the growth may simulate the appearance of a metastatic tumor.

The true pathology of this group of so called tumors is but poorly understood. Geschickter and Copeland¹⁵ have thought that the tumor begins subcortically and extends into the cancellous bone. The absence of periosteal reaction is characteristic. The growth is not primarily infiltrative, but expansive. The typical lesion consists of solid portions as well as numerous small cystic areas. The solid portions are friable, crumbly, granular masses, varying in color from yellow to dark red, but typically present the so called

currant jelly appearance. Extension into a joint cavity is extremely rare. Bloodgood described the general appearance of the tumor as simulating an old bruise. Sometimes fibrous areas may be palpated in the gross specimen, and occasionally the tumor is entirely encapsulated by fibrous tissue. The neoplasm may be easily scraped out of the bone cavity with a curette.

Microscopically the growth is found to be composed of large multinucleated giant cells loosely embedded in a stroma of smaller rounded, spindle and polygonal cells with large vesicular nuclei. The stroma is rich in various sized blood spaces; thin walled capillaries and newly formed blood vessels are not uncommonly seen. Geschickter and Copeland¹⁵ estimated that under low power magnification there are on an average 30 giant cells per field, each with from 15 to 200 nuclei. The cell outline may or may not be distinct. Areas of hemorrhage are conspicuous, and the giant cells are most numerous about such regions, as well as about small cysts and spicules of bone. An attempt at organization of the hemorrhage may be apparent. The origin of the giant cells is still questionable. Some consider them to be derived from transformed wandering endothelial leukocytes; others think of them as hypertrophied bone cells which are liberated by the absorption of the bone matrix; others think them derived from modified endothelium; while Lubarsch is of the opinion that they originate from abortive vascular sprouts. In addition to the above components of the giant cell tumor, aggregates of endothelial leukocytes are present, filled with lipid inclusions—the so called "foam cells."

It is a well known fact among pathologists that occasionally wide variance of opinion exists as to the microscopic diagnosis of this tumor. In general, in considering the diagnosis and prognosis of a bone tumor, the clinical, roentgenologic and the microscopic findings should be correlated, and too much reliance should not be placed on the histologic picture. It is generally conceded that there are many microscopic variants of the so called typical giant cell tumor. Kolodny has divided the tumor into four groups: simple giant cell tumor; xanthoma; the myxomatous type, and the telangiectatic type. He considered all four types as representing the same type of tumor, and believed the microscopic pathologic appearance to be of very little clinical significance. Stone and Ewing, as well as many other pathologists, have recognized various grades of malignancy in this neoplasm, noting zones of bone formation and the occurrence of very cellular areas of spindle cells. It is generally agreed that, from a microscopic standpoint, the malignant potentialities of a given tumor can be judged best by the appearance of the stroma cells. The character of the giant cells offers little aid in this regard. Although Stone and Ewing have recognized various grades of malignancy in these growths, they have not felt justified in including the atypical forms among the malignant osteogenic sarcomata.

The metastatic manifestations of giant cell tumor have raised some question as to its benignity. Simmons has stated that he has seen four cases in which death occurred from metastases of giant cell tumors. Coley⁹ re-

ported 50 cases of this neoplasm, nine of which metastasized. Stone and Ewing, on the contrary, have stated that rarely, if ever, does a true giant cell tumor metastasize. They report one case in which they consider malignant change was due to repeated operative trauma. They called attention to the fact that there is no satisfactory record of metastasis of a giant cell tumor in its original form. Kirklin and Moore did not observe metastases in any of their cases.

As to the metamorphosis from a benign to a malignant tumor, there is again a division of opinion. Ashhurst² believed that after several recurrences the tumor may change its nature and become malignant. Chatterton and Flagstad⁷ have observed the same phenomenon, even in cases in which the "trauma and operative interference have been mild." Simmons concurred. Coley¹⁰ has stated that there is a one in five chance that a growth which appears to be a giant cell tumor from the clinical and roentgenologic evidence will prove to be malignant. Geschickter and Copeland¹² championed the benignity of the tumor, and state that benign giant cell tumor never develops into an osteogenic sarcoma. Malignancy developed in none of the cases reviewed by Kirklin and Moore.

The giant cell tumor seems to bear a definite connection to osteitis fibrosa cystica, although it is not clear just how intimate that relationship is. As Simmons and Kolodny¹⁹ have shown, the older giant cell tumors show evidence of fibrosis, either as the result of advancing age, treatment, or fracture. Barrie considered the solitary bone cyst, osteitis fibrosa cystica and giant cell tumor as different phases of the same process—an attempt at repair following bone destruction. Geschickter and Copeland¹² have postulated that a bone cyst occurring in the metaphyseal region of one of the long bones of the young individual represents a healing phase of giant cell tumor—a conclusion based on clinical, pathologic and anatomic observations, and demonstrated by an analysis of numerous transitional lesions between these two entities.

This brings up the question of the correlation between the so called multiple giant cell tumors and parathyroid tumors. Alexander and Crawford¹ collected four cases from the American and seven from the foreign literature of multiple giant cell tumor. These authors quoted a communication from Codman in which he stated that he is skeptical about the existence of such a condition. Pfahler and Parry reported a case of what appeared to be a giant cell tumor of the mandible, and who later developed multiple bone tumors. Subsequently a parathyroid tumor was found. There were no biopsies of the bone tumors. Kolodny¹⁹ has been of the opinion that in the apparent multiple giant cell tumors one is probably dealing with osteitis fibrosa cystica. Geschickter and Copeland¹⁵ have cited the work of Jaffe in which this investigator showed that an experimental increase of the parathyroid hormone does not produce multiple tumors of the true giant cell type, although giant cell areas and osteitis fibrosa-like tissue may be formed in the bones of animals fed with an excessive amount of this substance.

Differential Diagnosis.—The giant cell tumor is an expansive type of growth, and must be differentiated from similar lesions occurring in the maxilla and mandible. The differential diagnosis of this tumor in the jaws is not different from that of the long bones, except in so far as several tumors indigenous to the jaws must be considered.

Dentigerous cyst occasionally offers some difficulty in the differential diagnosis. An unerupted tooth is always associated with the dentigerous cyst, and the cyst is unilocular with no trabeculae. However, sometimes a giant cell tumor may lie adjacent to an impacted tooth. In general, the outline of the dentigerous cyst is more regular, and most commonly is associated with an unerupted upper cuspid or with an impacted lower third molar tooth. The dentigerous cyst is lined with stratified squamous epithelium.

The radicular cyst ordinarily offers no great diagnostic problem, but there are cases in which the cyst attains large size and apparently loses its connection with the nonvital tooth from which it originated. The finding of vital teeth in the region of the tumor obviates the diagnosis of radicular cyst. This particular tumor is most commonly found in the upper lateral incisor area. The outline of this cyst is regular and is lined with stratified squamous epithelium.

The adamantine neoplasms are often quite difficult to differentiate from the giant cell tumors. Because of the trabeculation, the multilocular adamantinoma may simulate the giant cell tumor very closely. However, the adamantinoma is much slower in its development, the trabeculae are more clearly defined and usually extend throughout the tumor cavity, unlike those of the giant cell neoplasms, in which the trabeculations are often hazy and incomplete. If roentgen irradiation is employed it will be found that the adamantinoma is unresponsive, while the giant cell tumor quickly decreases in size under such treatment. The age of the patient and the location of the tumor do not offer much help, since both tumors occur in about the same age group and may occur in the same locations. Microscopically the adamantine epithelium is characteristic.

Osteogenic sarcoma offers diagnostic difficulty at times. However, in this tumor the periosteal reaction is usually evident, the reactive triangle of Codman is often present, the tumor is rapid in its development and microscopically most or all of the successive stages of bone formation may be demonstrable.

A central sarcoma, such as a fibrosarcoma, sometimes offers considerable difficulty, and often a microscopic section is necessary to differentiate the two conditions. The author recently operated a fibrosarcoma of the mandible in which the cortical bone was expanded but was still intact, there was no periosteal involvement, and the area of osteolysis simulated very closely that of a giant cell tumor. A biopsy, taken with the high frequency current, established the diagnosis, and jaw resection was done.

The giant cell tumor may resemble the lysis seen in a central carcinoma of the mandible, or may even resemble a carcinoma of the maxillary sinus.

Often the age of the patient will help to establish diagnosis, but occasionally a biopsy is required. In the opinion of the author, if the diagnosis rests between these two conditions, preoperative irradiation should be employed, despite numerous opinions to the contrary. If the lesion is of the giant cell type, marked diminution in its size will occur, whereas if the lesion is a carcinoma, the irradiation will render the malignancy more amenable to surgical therapy. The presence of a carcinoma of the prostate, thyroid or breast, or the establishment of a diagnosis of hypernephroma, will be of aid in ruling out metastatic carcinoma.

The giant cell tumor may sometimes be confused with a central fibroma. In the latter the growth is usually more tardy in its development, and the trabeculation is usually lacking. Fibro-osteoma should not be confused with giant cell tumor, since the lesion in giant cell tumor is entirely osteolytic in nature. Osteoma of the central type should offer no diagnostic difficulty. Multiple myeloma should not be confused with giant cell tumor and the uncommon solitary plasmocytoma of bone will rarely be mistaken.

Treatment.—The treatment of giant cell tumor has been revolutionized within recent years. Years ago amputation of an extremity, or resection of the involved area, was routinely advised. Although such therapy will undoubtedly give the greatest percentage of cures, it is by far too radical a procedure to be advised at the present time. Bloodgood⁶ recommended resection only when such a procedure is made necessary by the complete absence of the bony shell, or when resection will leave the part with equally good function. Coates,⁸ in a case of giant cell tumor of the upper jaw, has felt justified in maxillary resection for such a lesion.

At the present time the choice of treatment lies between curettage of the tumor bearing area, and roentgen irradiation, or a combination of the two. As early as 1910 Bloodgood⁴ sponsored curettage followed by chemical cauterization of the cavity. This method is still in common use. The author prefers to cauterize with the high frequency current, and agrees with Peirce,²² and others, in that roentgen therapy is always to be recommended following this procedure. Geschickter and Copeland¹⁵ have stated that "curettement properly performed in carefully selected cases is unquestionably the treatment of choice."

Many able men recommend no surgery in the treatment of this growth, but advise roentgen irradiation alone. Herendeen¹⁶ believed that most giant cell tumors can be cured by this method. Soiland and Costolow²⁵ obtained a complete response to roentgen therapy in every case. Pfahler and Parry²³ have thought curettement a disadvantage, and believed irradiation alone is definitely superior to surgery in the treatment of this group of tumors. Bloodgood, however, held that this method is more uncertain than curettement, is often more prolonged, and does not offer the advantage of a microscopic diagnosis in the doubtful cases. Geschickter and Copeland felt that postoperative irradiation of the tumor is of no particular advantage, and have stated that radium implantation has proved ill advised in the treatment of

giant cell tumors. A few investigators recommend the use of Coley's toxins in the treatment of the condition.

Prognosis.—If the tumor is left untreated it may reach tremendous proportions, and the patient may die from hemorrhage or from infection, without metastasis intervening. Kolodny²⁰ stated that occasionally, with no therapy whatsoever, either in the presence of a pathologic fracture, or without it, the tumor may be converted into a dry, firm fibrous tissue. In the center of such an area islands of active giant cell tumor may persist, although some such regions may degenerate and be replaced by cystic areas.

In 1919 Bloodgood⁶ reported on a series of 47 cases treated by this method, with no recurrence. Herendeen¹⁶ estimates that 25 per cent of the giant cell tumors recur after curettage. In a series of 105 cases treated by curettage, occurring in various parts of the body, Geschickter and Copeland¹⁵ reported a recurrence in 31 cases. They¹⁴ have considered the factors predisposing to recurrence as: patients over 35 years of age, advanced destruction of the bone shell, incomplete curettement, failure to use chemical or thermal cauterization subsequent to the curettage, and needless sacrifice of cortical bone at the time of the operation.

CASE REPORTS

Case 1.—A girl, age 19, gave a history of seven months' duration. At the onset she noted a painless tumor in the canine fossa and several loose teeth in the upper left maxilla. She consulted her dentist and an upper bicuspid was removed. The tooth socket healed uneventfully. Because of the persistence of the loose teeth an exodontist was consulted. He performed a biopsy two months after the onset of symptoms, which was reported as granulation tissue, although giant cells were present in the section. Seven months after the onset the patient consulted the author. She presented a nontender mass in the left gingivobuccal fold which extended from the region of the upper left first molar to the midline. Marked bulging of the cortical bone was present over this area, with egg shell crepitation. The mucosa over the tumor was intact and was deep red in color. The left maxillary sinus was opaque on transillumination. The roentgenogram (Fig. 1) showed the presence of an osteolytic lesion of the left maxilla, with extensive involvement of the maxillary sinus. A tentative diagnosis was made of giant cell tumor. The blood Wassermann was negative, and the blood and urine examinations did not show any abnormality.

The mass was explored, after confirming the diagnosis by biopsy, the anterolateral wall of the maxillary sinus was removed, and about 200 grams of dark red, friable tissue were removed. The ethmoid cells did not appear to be involved. A sinus window was made in the lateral nasal wall, and the sinus was lightly packed with iodoform gauze because of hemorrhage. The patient was discharged from the hospital on the third post-operative day, and ten days later was referred for roentgen irradiation. Four weeks after operation the opening of the maxillary sinus into the mouth had completely closed. The upper teeth were later removed for cosmetic reasons. Figure 2 shows the roentgenologic appearance at the end of four months. There has been some bone formation. After two years the patient has had no further symptoms and no apparent recurrence of the tumor.

Case 2.—A woman, 23 years old, gave a history of very short duration. The tumor mass was discovered by her dentist a few days prior to her consulting the author. There had been no symptoms referable to the tumor. The past history was negative except that she had been hospitalized for study a year previously, and was discharged with a diagnosis of neurasthenia. There had been no symptoms referable to the jaws or teeth.



FIG. 1.—Giant cell tumor of the maxilla involving the maxillary sinus.



FIG. 2.—Same case as shown in Fig. 1. Taken four months following operation.

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The patient was in a good state of nutrition and gave the general impression of being in rugged health. The blood calcium was 10 mg. per 100 cc. of blood and the serum phosphorus was within normal limits. The blood Wassermann was negative. R.B.C. 3,480,000, W.B.C. 7,000. Hemoglobin 72 per cent (Dare). The tumor mass extended from the region of the lower right first molar to the midline. The cortical bone on the buccal aspect was markedly expanded and egg shell crepitation was present. The mucosa was intact and was light purple in color. The roentgenogram (Fig. 3) presented the appearance of an osteolytic lesion, the lesion was irregularly lobulated, the trabeculae were scanty and incomplete, and there was no periosteal reaction. The diagnosis of probable



FIG. 3.—Giant cell tumor of the mandible.

giant cell tumor was made. At operation a horizontal incision was made in the lower gingivobuccal fold, the cortical bone thoroughly exposed, and after the diagnosis had been confirmed by a biopsy, the thin shell of cortical bone was removed, exposing the tumor bearing area. The field was easily visualized and the growth thoroughly removed. The cavity was loosely packed with iodoform gauze and the mucous membrane sutured with catgut. Two weeks following operation the patient was referred for roentgen irradiation. The patient made an uneventful recovery. Sixteen months after operation there has been no apparent recurrence of the tumor.

Case 3.—A boy, age 13, gave a history of a mass in the buccogingival region of the lower jaw of one year's duration. The patient had been told that he had a malignant inoperable tumor. There were no symptoms except those of a mechanical nature due to the size of the mass. On examination the patient appeared to be in excellent general health, and the tumor seemed to be causing no discomfort. A tumor mass presented in the buccogingival fold of the mandible extending from the region of the right first molar to the opposite cuspid. The mass was about the size of two tangerines placed side to side. The cortical bone was expanded, but the mucosa was intact over the tumor, pre-

senting a deep purple coloration. No tenderness was elicited on palpation. The diagnosis was made of a probable giant cell tumor. The roentgenogram (Fig. 4) revealed an osteolytic lesion extending from the region of the right bicuspid to the left cuspid, and the cortical bone was markedly expanded on its labial aspect. At operation the cortical bone was exposed as in Case 2; this was removed, and the tumor bearing area thoroughly curetted. Subsequent microscopic examination confirmed the diagnosis. The area was loosely packed with iodoform gauze and the mucous flaps sutured with catgut. The patient made an uneventful recovery and was referred for postoperative roentgen irradiation.



FIG. 4.—Giant cell tumor of the mandible showing extensive expansion of the labial plate.

tion. Three years after the operation there has been no evidence of recurrence of the tumor.

The microscopic picture presented by all three cases was very similar, and can briefly be described as coming in the category of the "typical" giant cell tumor.

CONCLUSIONS

(1) An adequate explanation for the histogenesis of giant cell tumors has not been given.

(2) As regards the nature of the growth, certainly some, and probably all, are neoplastic in character.

(3) In a large percentage of cases the lesion should be diagnosed from clinical and roentgenologic data, and should be considered in the differential diagnosis in the doubtful instances.

(4) Biopsy should always be taken, preferably with the high frequency current, prior to removing such neoplasm. The tumor should be treated conservatively by curettage, followed by either chemical or thermal (high frequency) cauterization of the tumor bearing area.

(5) Roentgen irradiation of suspected giant cell tumors should not be advocated to the exclusion of surgery, since in certain cases the condition cannot be definitely differentiated from malignancy. The patient should receive the benefit of biopsy, and in case of malignancy the involved jaw should be resected. If roentgen therapy alone is advised, a certain percentage of

doubtful cases will succumb to malignancy, which surgery could have averted.
(6) Postoperative roentgen irradiation should be advocated in all cases.

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SUBCHONDRAL TUBERCULOUS SEQUESTRA

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THE subchondral wedge-shaped sequestrum in tuberculosis occurs with sufficient frequency to warrant a more thorough study of its significance. A number of writers have recognized the existence of this interesting formation, but no detailed studies were undertaken from the diagnostic or pathologic viewpoint. The American and British literature has been particularly deficient in this field, probably due to the difficulty of obtaining autopsy material. A review of the material seen in this clinic during the past six years is presented here, entailing a statistical analysis of cases recognized clinically from 1929 to 1934 inclusive. A detailed histopathologic study of 20 anatomic specimens served as a basis for a number of interesting conclusions regarding the formation of these subchondral tuberculous sequestra.

Definition.—The term sequestrum, as used here, denotes a subchondral focus of tuberculous necrosis which appears in the roentgenogram as a more or less wedge-shaped area of increased density. In contradistinction to sequestrum formation in nonspecific osteomyelitis, the tuberculous sequestrum does not necessarily lie “free” in the sense of complete dissection or separation from the surrounding bony tissue. Consequently, the roentgenologic diagnosis of tuberculous sequestrum is made with several reservations in mind.

First, the affinity of necrotic tissue, especially tuberculous caseation, for lime salts is well established. This is significant, because the necrotic tuberculous area, although of no greater density than the surrounding tissues, may cast a denser roentgenologic shadow due to precipitation of lime salts within the necrotic area (Fig. 1).

Second, simple necrosis of bone marrow and bony trabeculae will prohibit further resorption of bone in the necrotic focus, whereas the surrounding living bone tissue becomes porotic. Actually, there may be continuity of bony trabeculae from the subchondral necrotic area into the living epiphysis without signs of separation (Fig. 2). The porotic zone represents an area of collateral hyperemia with increased osteoclastic resorption. This again indicates that the roentgenologic sequestrum formation is only occasionally a true sequestrum. As a rule, it is but the contrast between denser necrotic trabeculae and porotic living bone.

Third, hypertrophic arthritis may confuse the picture. An arthritic focus, by virtue of its sclerotic bony trabeculae, may resist resorption for a longer period than the adjacent bone. This does not mean that the process of resorption of the sclerotic bone proceeds at a slower rate, but merely that at a time when the surrounding bone has almost disappeared, the arthritic focus still

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FIG. 1.—Both sections are taken from a tuberculous vertebra. A shows numerous small calcified bony fragments *a*, diffusely distributed in caseated material *b*. B is in the same magnification as A, but shows a more circumscribed precipitation of lime salts *c* in tuberculous caseation *d*. These areas would cast a denser shadow in the roentgenogram than the surrounding tissues.

has bone within it. The temporal element is quantitative, not qualitative. The roentgenologic picture of such an area may simulate a sequestering focus (Fig. 3). Finally, the roentgenologic diagnosis of a wedge sequestrum is simple and absolute only when the focus is well separated and partially or wholly extruded into the joint cavity (Figs. 4 and 26).

Etiology.—Frequency: Before the days of the roentgen ray, Riedel¹ (1893) found sequestra in 45.2 per cent of 314 cases of tuberculosis (212 primary in bone, 102 primary in synovia) examined surgically. Menard² (1907), in 268 resections of tuberculous hips, discovered 87 joints (31 per cent) with sequestra, of which 81 appeared in the acetabulum, whereas only six sequestra were found in the femur, more in the neck and intertrochanteric region than in the head. In his article Menard stated that the surgeon required patience in searching for these sequestra. Garré³ (1913), quoted by Hellner,⁴ found 73 sequestra (8.5 per cent) in 849 instances of tuberculosis of the joints of the lower extremities. Sovetova⁵ (1929) discovered only 69

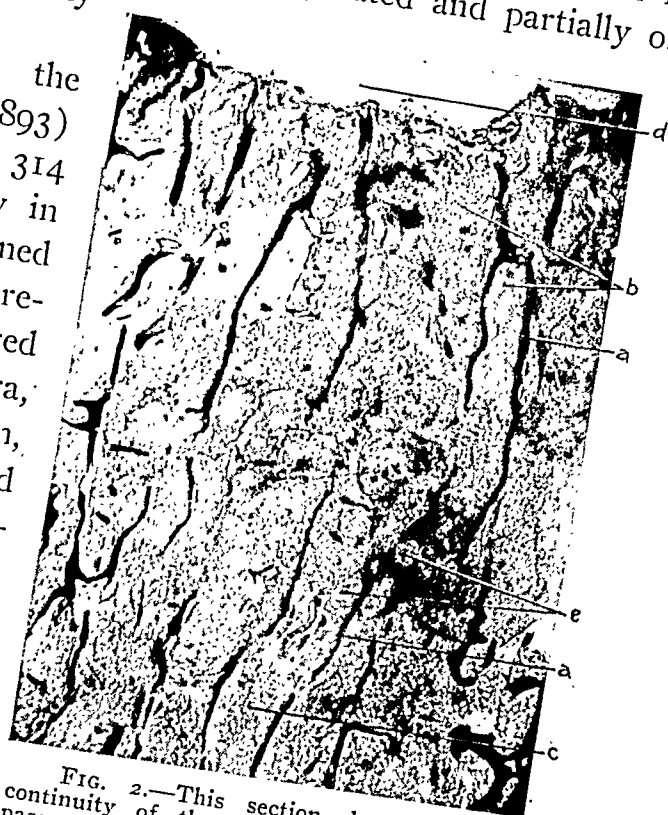


FIG. 2.—This section demonstrates the continuity of the bony trabeculae *a*, which pass without interruption from necrotic bone marrow *b* to living fatty bone marrow *c*. The infection is oldest near the joint cavity *d*, and extends into the epiphysis by resorptive tubercles *e*.

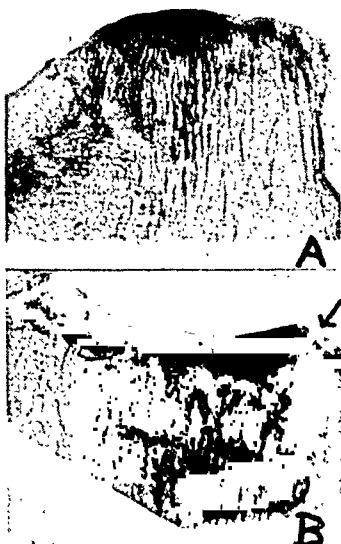


FIG. 3.—These roentgenologic positives of bone specimens indicate that an arthritic focus may simulate sequestrum formation due to the greater density of the sclerotic arthritic area. A shows a wedge-shaped focus bordering on the joint cavity with moderate porosis of the subjacent bone. The continuity of bony trabeculations rules out a true "free" sequestrum. In B the destructive process has apparently invaded the subchondral bone from the joint margin (note arrow) and has undermined the arthritic focus. The contrast between sclerosis and porosis is more marked, and the trabeculae seem to be interrupted in their continuity.

sequestra (4.1 per cent) in the routine examination of 1,443 roentgenograms of tuberculous joints. Hellner⁴ (1930), in contrast to other observers, found only six of the larger isolated sequestra (1.7 per cent) in 346 cases of bone and joint tuberculosis.

The foregoing brief review shows that there is no conformity among the various observers in their statistics of frequency. In part, this may be explained by the difference in frequency with which various joints are affected. For example, an author who has a large number of hips in his series would have a greater incidence of sequestra than an observer who concentrated on other joints, especially those of the upper extremity. Of course, the ideal method is that which could provide anatomic and histologic confirmation of cases diagnosed clinically (roentgenologically), but unfortunately, such material is seldom available.

The statistics compiled herein include only cases which were seen in this clinic within five years of the onset of symptoms and which had had no previous surgical treatment. Ninety-one cases of joint involvement in 86 patients were available and acceptable for clinical study. Of 68 cases of proved

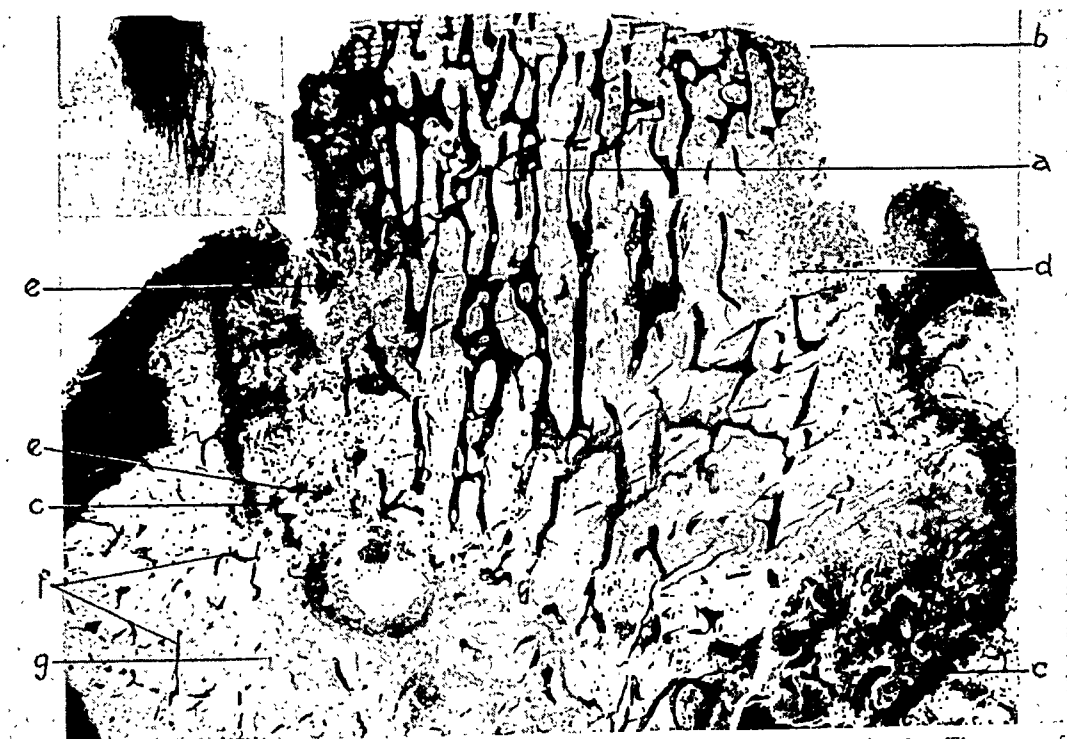


FIG. 4.—A well demarcated sequestrum *a* is being extruded into the joint cavity *b*. The zone of demarcation consists of tuberculous granulations *c*, necrotic debris *d*, and fragmented bone chips *e*. The contrast between the sclerotic necrotic trabeculae of the sequestrum and the extremely porotic living bone *f* in living fatty bone marrow *g* is marked. The inset depicts the roentgenologic appearance of this sequestrum.

Fig. 5.—(Case 33) Fungous tuberculous infection of the elbow in a 45-year-old male. A, after two years' duration of disease, shows a sequestrum of the lateral condyle of the humerus and of the coronoid process of the ulna. B and C were taken four months later and show better definition of the sequestra with separation of the ulnar focus.

A

B

C

tuberculosis, 21 had sequestra (31 per cent); there were ten sequestra (43 per cent) in 23 instances of unproved, but clinically certain, tuberculosis. Thus, 31 sequestra (34 per cent) were present in 91 joints. A comparative chart, showing the incidence of sequestra for each joint, as reported in the literature, is given in Table I. A number of sequestra are reproduced herewith by "positive" contact prints of their roentgenograms to illustrate the occurrence of subchondral sequestra in the various joints (Figs. 5 to 15 inclusive).

TABLE I
FREQUENCY OF OCCURRENCE OF SUBCHONDRAL SEQUESTRA
ACCORDING TO JOINTS INVOLVED

Author	Riedel (1893) No Roentgeno- grams	Menard (1907) No Roentgeno- grams	Garré (1913) No Roentgeno- grams	Sovetova (1929) Roentgeno- grams Only	Hellner (1930) Roentgeno- grams and Specimens	Finder (1935) Roentgeno- grams
Shoulder.....	50%	...	...	...	...	25%
Elbow.....	31%	...	...	...	...	57%
Wrist.....	15%	...	...	...	...	0%
Hip.....	70.4%	31%	9.2%	...	...	50%
Knee.....	37.7%	...	5.5%	...	...	24%
Ankle.....	38.5%	...	7.5%	...	...	22%
Average.....	45.2%	31%	8.5%	4.1%	1.7%	34%

The presence of sinuses apparently had little bearing on sequestrum formation. Analysis revealed that sinuses occurred in 26 per cent of the cases in which sequestra were present, while 28 per cent of the cases without sequestra had sinuses. The tuberculous sequestrum formation, therefore, is apparently independent of secondary retrograde superinfection along a sinus tract, causing a complicating nonspecific osteomyelitis.

Pathogenesis.—The similarity of the wedge-shaped focus in subchondral bone tuberculosis to the wedge- or triangular-shaped infarct seen in parenchymatous organs has led many authors to consider the wedge-shaped sequestrum as a form of bony infarct, due to vascular occlusion. The publication of Koenig⁶ (1896) stated that all oval or cone-shaped areas of necrosis were to be regarded as evidence of embolism; clumps of tubercle bacilli, alone or within tuberculous débris, lodged in end arteries of the epiphysis and infected the areas supplied by the obstructed vessel.

In 1912, Fraser⁷ experimentally injected lampblack into vessels of the epiphysis. He found that triangular areas were colored in those joints where there was a connection between the blood vessels in the capsule and those in the substance of the surrounding bones. He believed, therefore, that primary vascular infection developed at the site of synovial reflection and entrance of vessels. This was mainly the case in the lower extremities. There was no

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FIG. 6.—(Case 12) A sequestrum is present in the lateral condyle of the humerus of a 57-year-old male after 21 months' duration of the disease.



FIG. 7.—(Case 6) A 62-year-old female presented a sequestrum of the articular aspect of the medial malleolus only four months after the onset of symptoms.

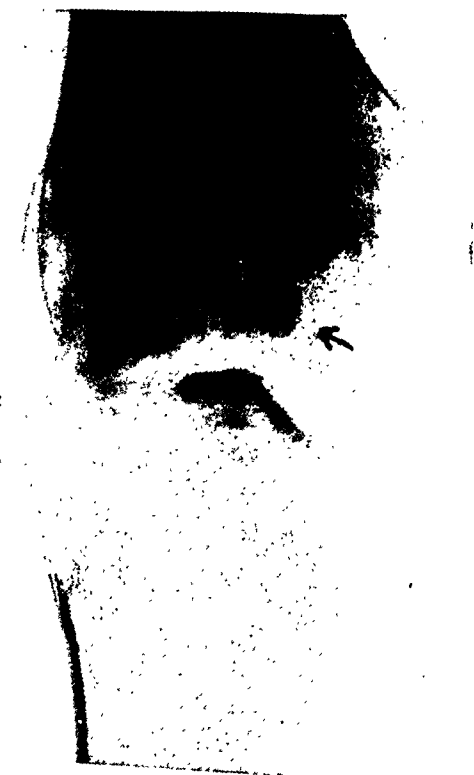


FIG. 8.—(Case 39) A 21-year-old female showed a tuberculous sequestrum in the medial portion of the femoral intercondyloid notch after 13 months' duration of the disease.



FIG. 9.—(Case 31) Sequestration was noted in both condyles of the femur of a 23-year-old male, whose symptoms were present for three years. The medial sequestrum (black arrow) is being extruded into the joint cavity after four and a half years. The lateral sequestrum involves almost all of the articular surface of the condyle. Its resemblance to a calcified semilunar cartilage is ruled out by the continuity of bony trabeculae into the sequestrum. Both areas were demonstrable at operation.

particular site of election in the bones of the upper extremity, since there was but little connection between capsular and osseous vessels.

In 1923, Nussbaum⁸ showed that the arteries of the epiphyses, unlike those of the metaphyses, are not end arteries. This concept is now generally accepted and refutes Koenig's assumptions. One year later, Phemister⁹ showed quite accurately that tuberculous invasion develops mainly from the joint margins; he ascribed this process to a pressure effect, or rather to a lack of protective pressure at the nonweight bearing margins.

Although these theories differ in their views as to the mechanism of infection, they generally recognize that invasion most frequently chooses the joint margins as the site of predilection. While a combination of the mentioned factors may be responsible, it also seems reasonable to assume that secondary

tuberculous infection of bone starts at the joint margins because the actual physical resistance there is decreased. In this region the joint cartilage is of slight thickness and the bony epiphysis is covered by only a thin layer of periosteum and synovia. This thin protecting membrane can be destroyed easily, permitting resorption of cortex and infection of bone marrow.

It is well known that the marginal portion of a joint, especially the knee, forms a site of lessened resistance. In suppurative processes, or in any form of arthritis combined with increased intra-articular pressure, these areas become affected first. They yield to in-



FIG. 10.—(Case 20) The upper pole of the head of the femur in a 20-year-old male presents a large sequestrum. Duration of the disease was two years.

creased pressure by bone resorption, which gives the characteristic eroded foci seen in the roentgenogram (tuberculosis, hemophilia, suppurative arthritis, etc.).

A second site of predilection in this series occurred in areas showing arthritic changes. This is in contradiction to the statement that hypertrophic arthritis is a protection against tuberculous invasion. This conclusion was drawn after examining microscopically tuberculous specimens obtained from autopsy material of persons of advanced age, in whom the incidence of hypertrophic arthritis was relatively frequent. Two reasons for this predilection suggest themselves: first, these areas usually lack the protection of joint cartilage; second, constant mechanic irritation in these regions probably decreases the resistance of the bone marrow to tuberculous infection.

The protective rôle of joint cartilage was mentioned already in connection with infection invading bone at the joint margins. Thus, it is quite possible that while no signs of specific infection are seen in those areas where the joint cartilage acts as a protective barrier against bone invasion, tuberculous infec-

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tion may be already advanced in areas of subchondral sclerosis (arthritis deformans), which lack the protection of a cartilaginous cover.

The accessibility of the spongy bone in areas surrounding a sclerotic, hypertrophic arthritic focus, combined with mechanic irritation and weakening of the spongy bone, makes invasion of the tuberculous granulation tissue relatively easy. At first, necrosis of bone and bone marrow leads to a rather sharp demarcation from the living tissues, but without true separation (Fig. 3). However, extensive caseation may result in sequestration of the necrotic area. In such cases, the bony tissue, which is dense, shows irregular outline of the trabeculae. Its density contrasts strikingly with the porotic surroundings. The density is due partly to sclerosis of arthritis and partly to necrosis of bone before resorption could progress very far. The surrounding porosis

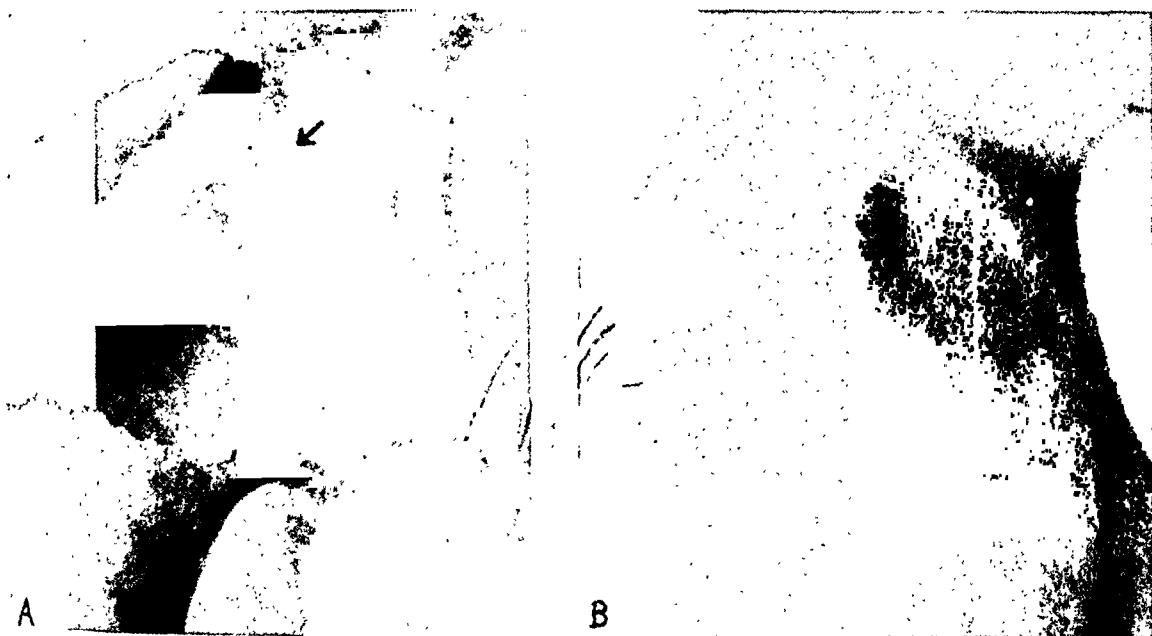


FIG. 11.—(Case 11) Symptoms were present for two years in the hip of a 27-year-old male. The white arrow in A points to a sequestrum, which stereoscopically lies behind the head of the femur. The origin of this sequestrum is marked by the acetabular defect above. B was taken three months later (two months after an extra-articular fusion of the hip). The acetabular sequestrum has become resorbed or is now overshadowed by the large area of necrosis involving the head.

is directly due to resorption by tuberculous granulation tissue. Therefore, the density of these areas in the roentgenogram cannot be taken simply as an expression of necrosis of bone tissue; the arthritic factor must also be evaluated. In some cases, gross inspection, as well as the roentgenogram, reveals a very dense focus of bone tissue separated from the otherwise markedly porotic joint end by a zone of dissection; the focus may separate enough to protrude considerably into the joint cavity (Fig. 4).

The development of a wedge-shaped focus of necrosis, according to most authors, requires at least three months from the time of onset of the infection until a roentgenologic diagnosis can be made. At least ten weeks are necessary for metaphyseal emboli-formed sequestra to become recognizable. The upper limit is unknown, but these foci may form after many years. The rate of disappearance of the wedge-shaped sequestrum is still more problematic. Kisch and Grunert¹⁰ report a case in which the sequestrum disap-

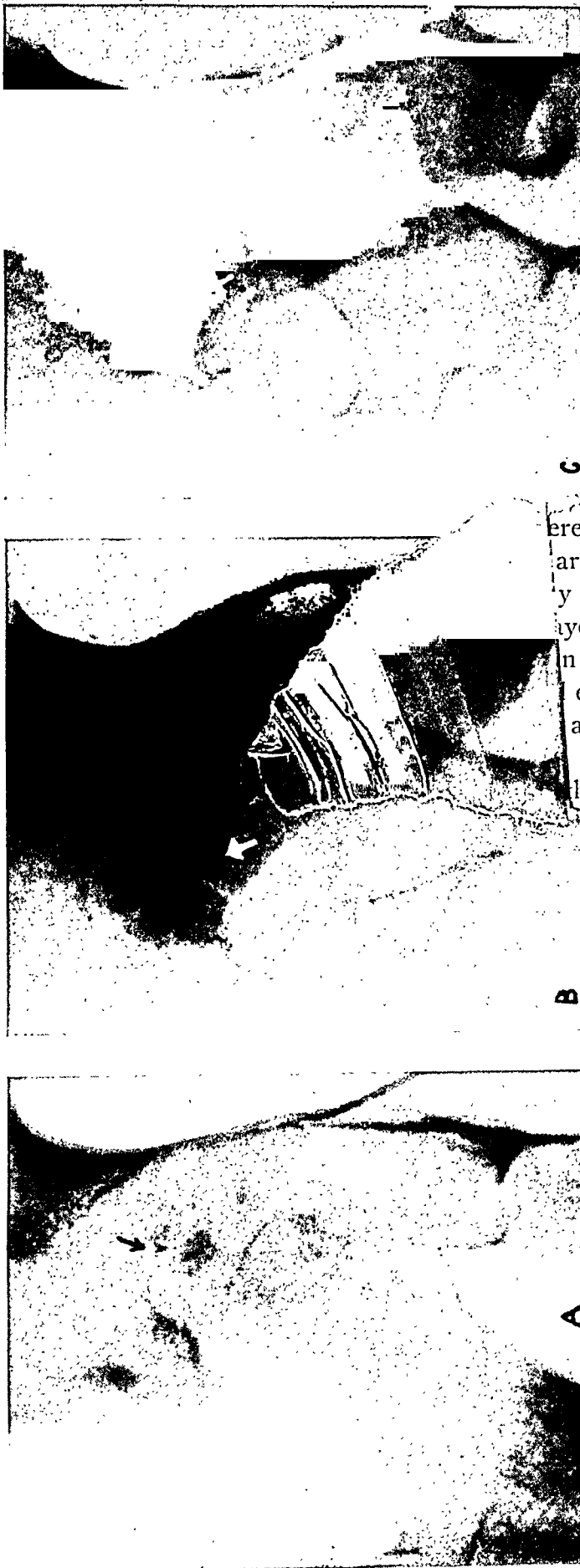


FIG. 12.—(Case 8) A 14-year-old female had had symptoms for one year when A was taken, immobilization, shows increase in size of the area of necrosis. B, taken after ten months of an acetabular sequestrum. C, no significant changes from B.

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peared gradually within 14 months after iodine by mouth, heliotherapy and hyperemia were instituted. Several cases, followed in this clinic, furnished good roentgenologic evidence of development and disappearance of sequestra (Figs. 12, 13, 14 and 15).

Trauma, erosion and molecular disintegration may lead to wearing down of the sequester in the form of tiny sequestra or bone sand. In other cases, the sequester may be extruded into the joint cavity or into a sinus tract, leading outside the body. Sequestra which become encapsulated may be protected from further resorption and so remain unchanged indefinitely.

Histopathology.—Contrary to the usual concept that tuberculous infection of joint ends is primary in the bone, the specimens studied in this series showed secondary bone involvement in all cases, except four. This may be

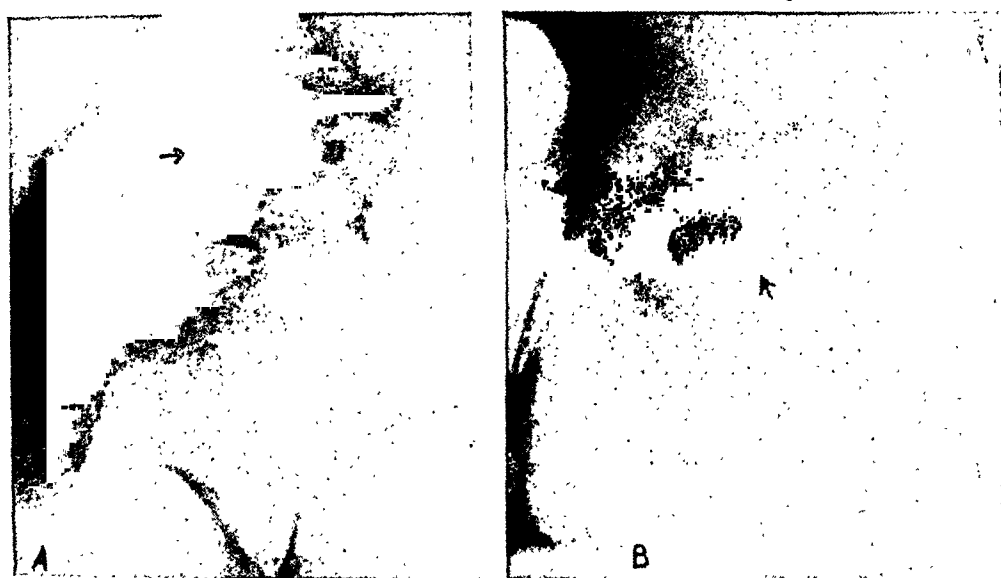


FIG. 13.—(Case 22, Figs. 13, 14, and 15) This series, occurring in a 24-year-old male with symptoms of six months' duration, demonstrates the possibility of disappearance of sequestra. After six months A shows a well demarcated acetabular sequester. After ten months the sequester, as seen in B, has dropped somewhat and is lying free in the joint cavity.

due to the fact that the histologic material which was derived from individuals of advanced age may give a distorted picture; it is possible that in younger persons the primary bone infection might prevail. However, the question of primary or secondary bone involvement can be settled only by studying material in which the disease was of relatively short duration. When the disease is of longer standing, it is possible that a primary bone involvement may break into the joint, where a secondary tuberculous arthritis develops. The process may then become widespread and reinfect the bone tissue. On the whole, such material would be unsatisfactory for accurate determination as to whether bone invasion was primary or secondary.

Primary Bone Involvement.—Primary subchondral bone tuberculosis presents certain histologic differences from the more frequent secondary form. In earlier cases the focus of infection is more centrally located within the epiphysis; the subchondral marrow spaces are fairly well preserved. Subsequently, the latter may become involved also, but they show signs of more

recent infection and bone resorption. These findings speak against primary vessel occlusion and resultant infarct type of necrosis.

The only instance which suggested the possibility of a vascular involvement as the cause of necrosis was seen in a case where the marrow spaces

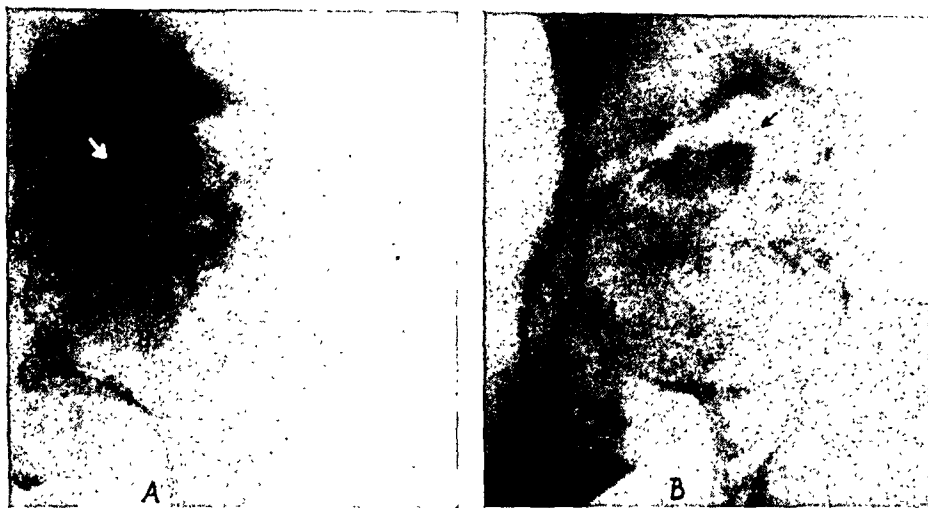


FIG. 14.—(Case 22, continued) In A the sequestrum seems to be smaller, after 15 months. In B, after 18 months, the sequestrum lies behind the head of the femur.

were involved more extensively by necrosis than by invasion of tuberculous granulations. The involved focus was more or less triangular-shaped, and at the apex an artery, vein and enlarged lymph sinuses could be seen (Fig. 16). Lymphocytic infiltration was increased around these vessels; the wall of the

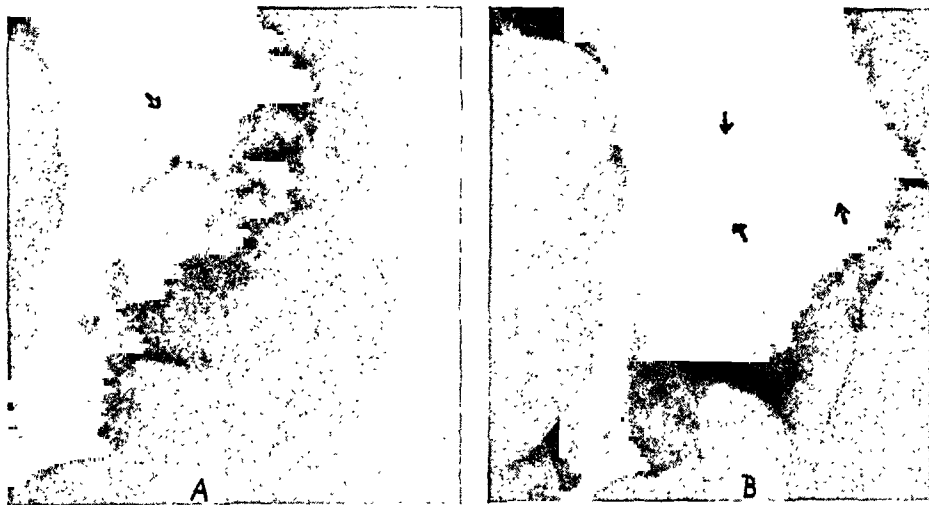


FIG. 15.—(Case 22, continued) Twenty-eight months after onset of disease, A reveals the relatively small remains of the original sequestrum (black arrow). A new, secondary area of necrosis (white arrow) is being sequestered from the acetabulum. A small focus seems to be developing in the superior lateral pole of the femoral head. This focus is confirmed in B, taken after 52 months. The changes in the acetabular sequestra seem to be at a standstill.

artery was edematous, but not infiltrated. The infection of the joint most likely extended along the lymph vessels into the deeper marrow spaces, apparently leading to a toxic necrosis, rather than an aseptic necrosis of bone marrow by vessel occlusion.

This instance of subchondral necrosis, whose configuration suggests a wedge sequestrum, can be attributed to propagation of infection along vessels. It must be conceded, therefore, that the wedge sequestrum of tuberculous necrosis may be the result of preformed anatomic structure. As a rule, however, the tuberculous necrosis, primary or secondary, is not related to primary vascular alterations.

The primary infection, which develops within the epiphysis, invades the surrounding tissues centrifugally in the form of resorption tubercles. As reactive changes occur in the living tissue bordering on the original epiphyseal focus of bone infection, walling off may be initiated by a tendency to fibrous

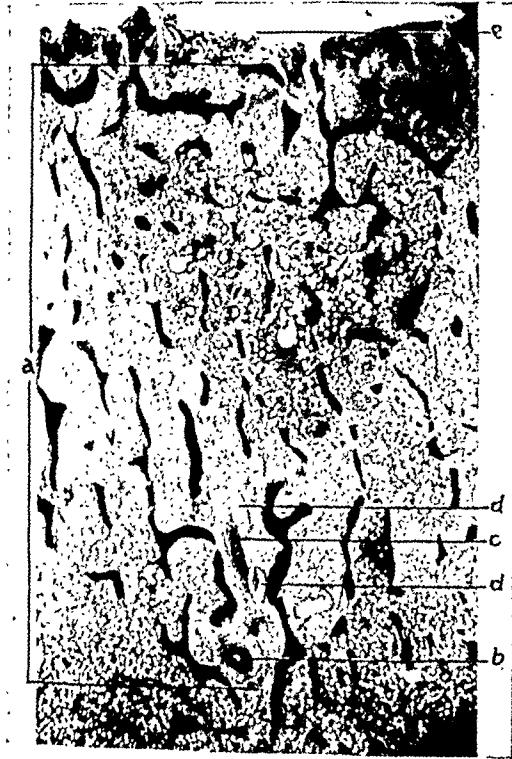


FIG. 16.—The possibility of a "bone infarct" due to vascular involvement is sometimes demonstrable. At the apex of the wedge-shaped area of necrosis *a* are an artery *b*, vein *c*, and lymph sinuses *d*. The necrosis, which extends fan-like towards the joint cavity *e* is probably toxic, independent of tuberculous granulations.

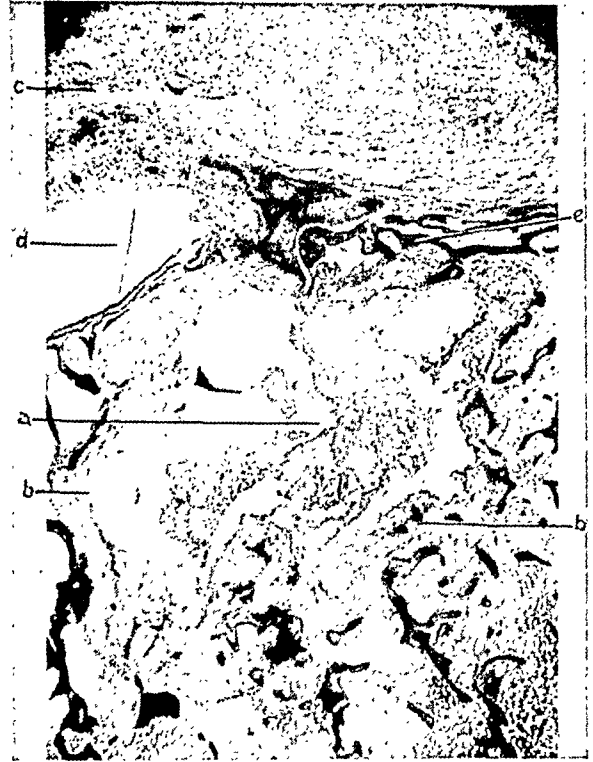


FIG. 17.—The subchondral abscess *a*, whose wall is lined by tuberculous granulations *b*, is in connection with the joint cavity *c* through an isthmus between the junction of marginal joint cartilage *d* and cortex *e*. The joint, which is already filled with tuberculous caseation, may have perforated the bone at this point, leading to abscess formation. On the other hand, the abscess, even though secondary to the joint infection, may have developed as a separate focus, and is now about to break into the joint.

condensation along the borderline of granulation tissue between living and necrotic bone tissue.

As the tuberculous process extends, the infection ultimately reaches the joint cartilage; this barrier impedes its progress in a centrifugal direction toward the joint cavity, but permits spreading of the disease along the subchondral bone marrow spaces. Thus, the tendency to check dissemination in the more central portions of the epiphysis, where the infection is older, while the subchondral spreading is still active may lead to the formation of a sequestrum whose shape is more or less of a wedge. The definitive shape apparently depends upon the speed with which walling off occurs at the pri-

mary site: if it is rapid, a fairly sharp apex should result, giving a triangular form; if the process is slower the apex will be wider and a wedge shape is assumed.

As the infection spreads subchondrally, the cartilage eventually may be resorbed from below, allowing the infection to break into the joint cavity. The joint invasion may be preceded by abscess formation in the subchondral marrow spaces, which become filled with tuberculous pus and necrotic bony trabeculae. The wall of the abscess is formed by tuberculous granulations, but there is not true sequestrum formation. Finally, the abscess breaks into the joint, frequently selecting the margin of joint cartilage and cortex, leading to a secondary tuberculous arthritis (Fig. 17).

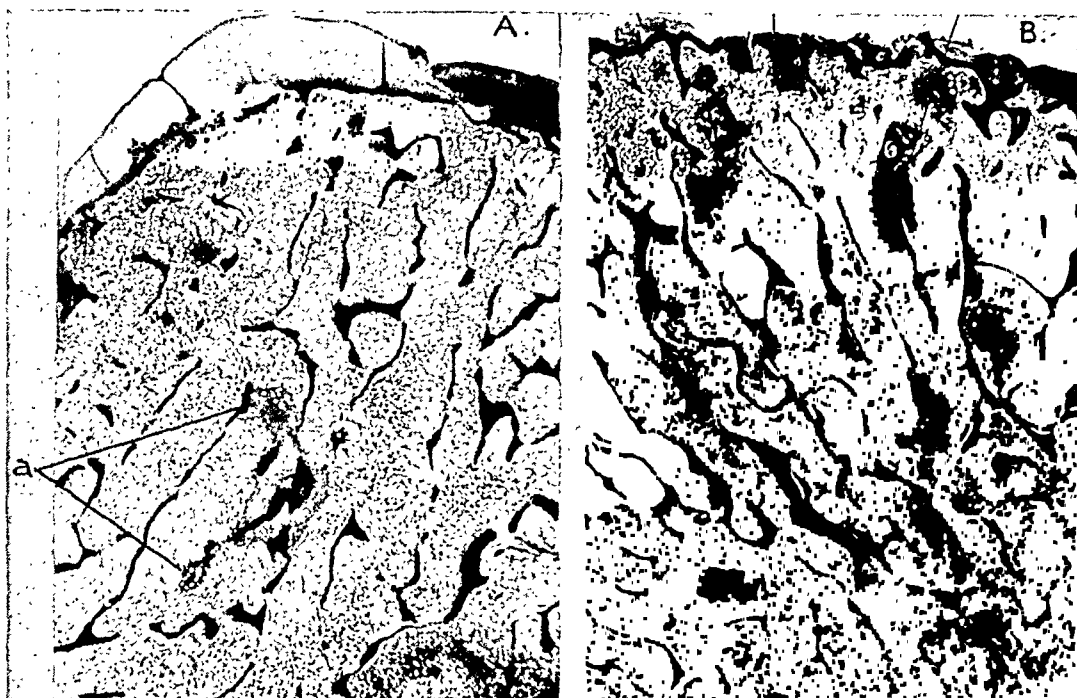


FIG. 18.—The tuberculous infection is seen spreading by continuity along the paratrabeular lymph sinuses *a* into the epiphysis. This is similar to the dissemination in B, which is taken from a case of suppurative arthritis with secondary osteomyelitis (after Freund¹¹).

Secondary Bone Infection.—Tuberculous subchondral necrosis most often is due to secondary invasion of bone marrow from an extensive joint infection. Ordinarily, the infection from the joint spreads through the openings between the bony trabeculae by continuity. The infection follows along the margins of the trabeculae, very similar to the invasion in a suppurative process (Fig. 18). Necrotic bone marrow with large fat holes may surround several long living bony trabeculae, which still show a preserved nuclear stain. As Freund¹¹ has shown in his study of secondary nonspecific osteomyelitis of the epiphysis, joint infection may follow lymph sinuses along the endosteal surface of the bony trabeculae (Fig. 18).

The spread of infection and tuberculous granulations in the subchondral zone leads to destruction of cartilage from below, although the more distal cartilage may remain fairly well preserved. As the granulations accumulate



FIG. 19.—The joint cartilage *a*, although undermined by tuberculous granulations *b*, is still fairly well preserved down to its calcified layer. The dissection of the cartilage from below has resulted in its complete desquamation.



FIG. 20.—The advance of the infection into the subchondral bone is marked by a zone of resorptive tubercles *a*, which sharply demarcate the necrotic bone *b* from the living bone *c* and fatty bone marrow *d*; deeper in the epiphysis. The superficial layers of tuberculous granulations *e* have undergone necrosis *f*, especially bordering on the joint cavity *g*, where the process is oldest.

they may dissect the overlying cartilage, often including the calcified layers, from the subchondral bone, so that a relatively large portion of joint cartilage may desquamate (Fig. 19).

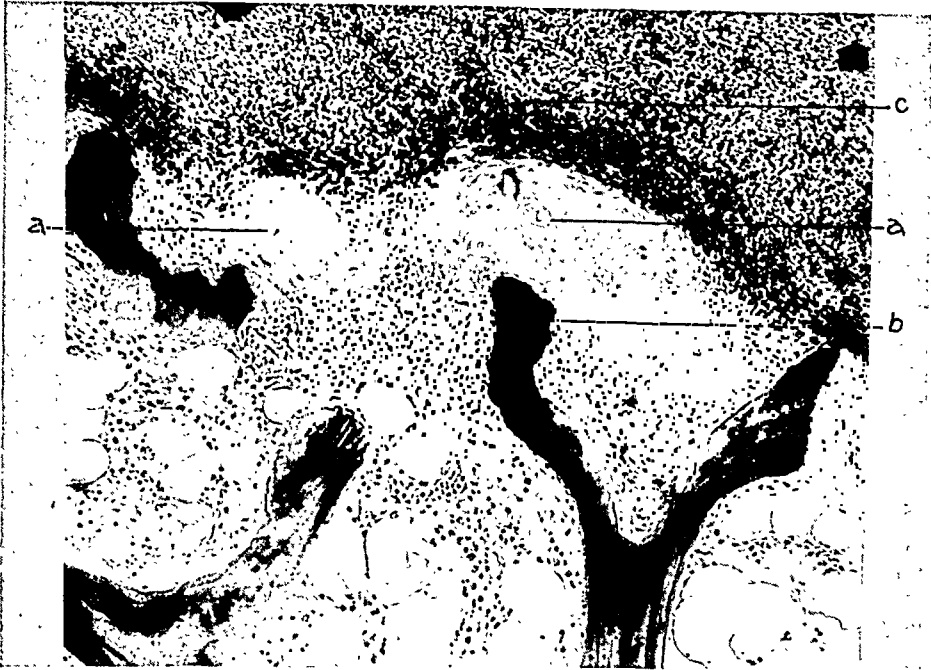


FIG. 21.—The fibrous cartilaginous caps *a* overlying the bony trabeculae *b* represent an attempt at regeneration of a new joint cover after destruction of the original cartilage by invasion of tuberculous granulation tissue *c*.

The underlying exposed marrow spaces become filled with caseated material, and by confluence of several necrotic foci a large area, simulating a



FIG. 22.—The bony trabeculae have formed a transverse lamella *a* in an attempt to halt the spread of infection into the epiphysis. Towards the joint the necrotic bony trabeculae *b* lie in necrotic tissue *c* and tuberculous granulations *c*; towards the epiphysis the bony trabeculae *f* are alive in fatty bone marrow *g*.

wedge, may result. However, the shape of sequestra more common to secondary bone involvement resembles a trapezoid or butterfly. That the

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wedge shape is more or less accidental can be seen in some cases, where caseation of subchondral bone marrow occurs over a fairly large area, but the extension deeper into the epiphysis is rather localized.

The demarcation of the necrotic area is usually represented by a zone of tuberculous granulations, which is the advance zone of infection (Fig. 20). In the active early stages there may be a fibrinous exudate, which contains a great many epithelioid cells and is in firm connection with the tuberculous granulations, which show a great number of epithelioid and giant cell tubercles. Tubercles are also found in the bone marrow, beyond the zone of granulation tissue. Osteoclastic bone resorption is greater there, and the nearby marrow spaces show marked hyperemia, edema, and cellular infiltration. Plasma cells and lymphocytes predominate, probably as a response to the specific infection. Not infrequently, the interposed zone of tuberculous granulation tissue is loaded with small fragments of bony trabeculae, which frequently show nice examples of bending and splitting of lamellae on their convex sides. This zone, however, does not effect a distinct dissection of the infected necrotic area.

As the granulation tissue grows older it develops a fibrous condensation. The fibrous wall may form a protective barrier for the underlying marrow spaces against further invasion from the joint cavity. This fibrous tissue may even develop new cartilaginous islands over prominent bony trabeculae, where gliding occurs (Fig. 21). Such cartilage formation represents an attempt to regenerate a cartilaginous joint cover; it is interesting that it may occur despite the presence of active tuberculosis.

In cases of extensive tuberculosis of the fungous type, the subchondral involvement may be very gradual and without apparent foci of marrow caseation. This form has to be differentiated from the more frequently observed type described above, where rather large areas of secondary bone tuberculosis have developed.

An uncommon type of separation is characterized by the formation of demarcating bony lamellae which sharply separate the sequestrum with its surrounding tuberculous granulations from the noninvolved bone marrow spaces (Fig. 22). These demarcating bony laminae are the result of a complex process of bone apposition and bone resorption taking place on the sur-

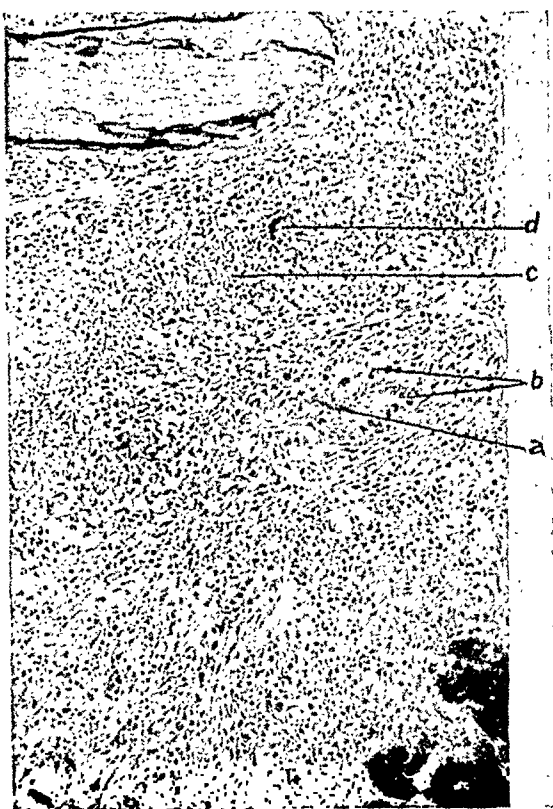


FIG. 23.—Osteogenesis on a fibrous tissue basis may occur even in the presence of active tuberculosis. Osteoid tissue *a* is seen surrounded completely by a layer of osteoblasts *b*, although only separated by a few micra from a tubercle *c* containing a Langhans giant cell *d*.

face of bony trabeculae. The structure of the bony trabeculae is also complex, and consists of many dark blue, lacunar cement lines which separate old (sometimes necrotic) bone tissue from the new living bone. Some bone also develops simply on a fibrous tissue basis with osteoid and osteoblasts; this occurs within the tuberculous granulation tissue despite the presence of tubercles (Fig. 23).

In addition to demarcation of necrotic from living bone by caseous material, granulation tissue, fibrous tissue or bony lamellae, it is possible to find separation effected by trauma. The mechanic resistance of the joint end is materially weakened by the invading infection, so that by relatively insignificant injury a marginal portion (as in the femoral condyle, for example) may be broken off. This is illustrated in places where a zone of separation, without any interposed tuberculous granulation tissue, can be found extending straight through necrotic bone toward the joint surface. This space represents an intra-articular fracture line (Fig. 24).

Necrosis.—The extent to which changes develop in necrotic or sequestered bone tissue is largely dependent upon the rapidity or slowness with which death of the bone marrow and bony trabeculae occurs. If the advancement of the tuberculous process is gradual, then reactive changes as they occur in living bone tissue should also be manifest in the necrotic areas in the form of bone resorption.

Quite typically, a region gradually invaded by tuberculosis shows subchondral bone denuded of joint cartilage and covered by a zone of tuberculous granulations, whose superficial layers characteristically undergo necrosis (caseation). The deeper layers (at a greater distance from the joint cavity), however, are extremely rich in tubercles, some of which have fibrous capsules. The bone tissue included in this area has undergone extensive resorption and is lacunar in outline. The other portions of the epiphysis show a considerable degree of osteoporosis, which is most marked in the affected area. By progression of the tuberculous infection an extensive portion of the epiphysis may become overrun and undergo caseation. Here, too, tuberculous granulation tissue marks the advance of the invading infection. The bony trabeculae in the demarcated area of necrosis show more or less marked signs of bone resorption, depending on the celerity with which the infected area became necrotic. Thus, this process may lead to demarcation and sequestration of extensive areas without presenting primary tuberculous joint sequestra.

The bone marrow and trabeculae of a sequestrum which has been demarcated by a rapid infectious process does not have time to undergo reactive changes. As a consequence, the bony tissue is practically of the same density throughout the entire sequestered or necrotic area; bone resorption is almost entirely absent; and the margins of the trabeculae are relatively smooth. The surrounding necrotic areas, however, display different stages of destruction, and the trabeculae in these areas show corresponding variations in density. If the density of the trabeculae of the sequestrum is approximately

the same as that of the surrounding bone tissue, it may be assumed that the focus of necrosis is of rather recent origin.

As a rule, necrosis of bone marrow is never so rapid that a sequestrum forms without some traces of reaction. Therefore, although a necrotic area may appear to be of equal density throughout, the bony trabeculae very close to the zone of tuberculous granulations usually show definite lacunar outline, although included in caseous material. This indicates that the subchondral infection extended into the epiphysis for a short time, at any rate, before necrosis of the whole area occurred. This is in contradistinction to the infarct type of necrosis where death of involved tissue occurs simultaneously.

Interpretation of Necrotic Tissue.—The chief difficulty of interpreting changes in tuberculous, or suppurative, necrosis of bone marrow is that disintegration of structures makes it impossible to determine what type of tissue underwent necrosis. In aseptic necrosis it is usually quite easy to make out the histologic structure, so that tissual classification can be made despite lack of nuclei. Such recognition in caseated bone marrow is almost impossible, because decay and disintegration of tissue into an amorphous material apparently occurs so rapidly that the structure affected loses its histologic characteristics almost immediately. Thus, it is quite possible that sudden caseation of fatty bone marrow may present, in a very short time, the same picture as disintegration of tuberculous granulation tissue, cellular bone marrow or even fibrous bone marrow.

The presence of fat holes in caseous material is not always an indication of origin from fatty bone marrow, because similar fat holes can also be found in caseated lymph nodes, where the preexisting amount of fat is certainly inconsiderable. The fat holes may be due to the content of degenerated fatty substances in caseated material. In certain cases of florid tuberculosis, for example, where a rapidly spreading secondary tuberculous osteomyelitis is present, necrotic bone marrow foci show irregular central fat holes, apparently formed by confluence of necrotic fatty bone marrow cells. Quite typically, the necrotic foci show caseated centers, surrounded by many fat holes and by tuberculous granulations, rather than fatty bone marrow. In that event, the arrangement of the fat holes around the center of necrosis probably is due to the extraction of fatty substances at the periphery of necrotic areas.

The only reliable landmark, as is often the case in bone pathology, lies in the bony trabeculae, whose outlines and density offer interpretative data. The different stages of osteoporosis, and especially osteoclasts, often furnish a rather detailed explanation of necrosis of bone tissue in various periods. These changes have already been considered. However, all bone resorption is not a simple osteoclastic process. While it is quite true that the bony trabeculae are frequently lacunar in outline, they may nevertheless be smooth and thin. At the endosteal surface mononuclear cells can be seen; in some instances, these cells are certainly capable of bone resorption.

An interesting finding is the presence of osteoid layers on trabeculae

included in tuberculous granulations. The borderline between calcified and noncalcified bone tissue is sometimes sharply lacunar; quite often, however, there is gradual fading from calcified to noncalcified tissue. The significance of these osteoid layers is still doubtful, but their appearance in connection with rapid bone resorption suggests halisteresis supplementing cellular bone resorption. On the other hand, it is also possible that the continuous process of bone apposition, as it occurs throughout life, may become altered by an inflammatory process, which causes local changes in tissue chemistry, most likely affecting the pH . This alteration may be sufficient to account for the formation of osteoid tissue.

Fate of Sequestra.—Following necrosis of the dissecting tuberculous gran-



FIG. 24.—Trauma may effect the separation of a necrotic focus *a* so that the zone of separation *b* represents an intra-articular fracture space, as yet unattended by reaction in the adjacent necrotic tissue *c*. The sclerosis of the necrotic trabeculae *d* stands out in contrast to the porotic living trabeculae *e* in fatty bone marrow *f*. The inset shows the roentgenologic appearance of the sequestrum.

ulation tissue, further changes in the sequestrum itself can occur only by trauma or molecular disintegration. The rôle that trauma plays in breaking off portions of the articular surface has already been mentioned. Smaller fragments of spongy bone are very frequently found on the joint surface in the more advanced stages of tuberculous arthritis, and it is quite possible at times that even greater parts of the surface may break off. This is especially true in cases where a focus of necrotic sclerotic trabeculae separates from the adjoining porotic bone and protrudes into the joint cavity. This elevation leads to more irritation of the focus due to motion which is especially marked at the zone where sclerotic bone meets porotic bone. The motion leads to decomposition of bony trabeculae into smaller fragments,

exclusive of osteoclastic resorption by tuberculous granulations. The marrow spaces along this zone contain many small irregular pieces of calcified material, evidently fragmented trabeculae. Thus, trauma appears to be as important a factor in the separation of tuberculous sequestra as the active process of dissection (Fig. 24).

If considerable portions of the subchondral bone are lost by erosion, the

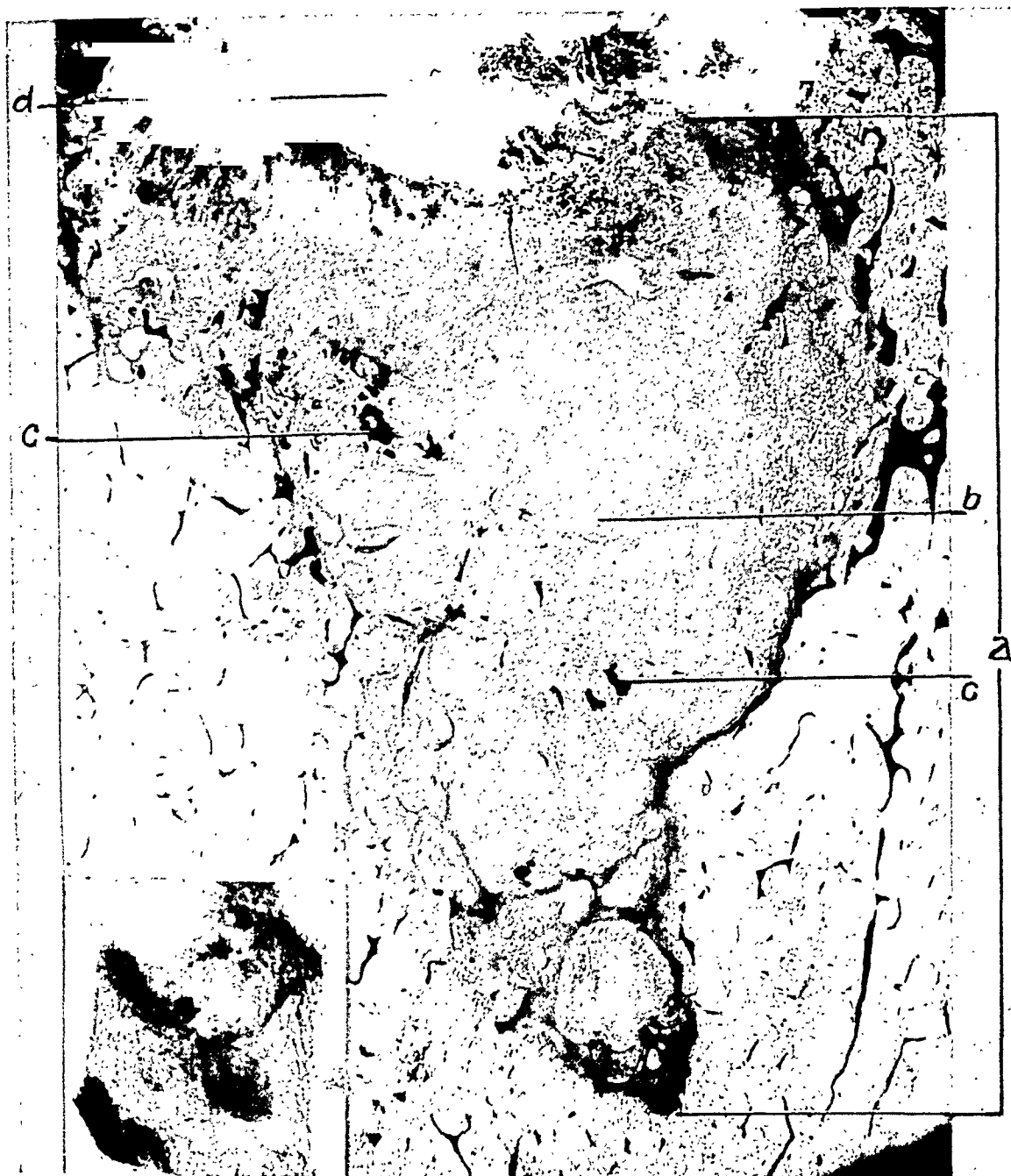


FIG. 25.—The large triangular defect in the subchondral bone *a*, filled by necrotic debris *b* and small bony fragments *c*, represents the area previously occupied by a sequestrum, which probably has been extruded into the joint cavity *d*. The extreme porosis of the surrounding bone tissue is marked. The inset illustrates the roentgenologic appearance of the bony defect.

sequestrum, instead of protruding into the joint cavity, may lie in a depression of the joint surface. In part, this may be due to a relative increase in the size of the bony defect by removal of bony fragments through resorption by tuberculous granulations. On the other hand, the sequestra may be completely extruded into the joint cavity, leaving a triangular defect in the

joint end, which is surrounded by porotic bone tissue and filled by caseated material containing a few bony trabeculae with lacunar outline and markedly decomposed joint cartilage (Fig. 25). This would indicate that the sequestrum is partly resorbed, partly extruded into the joint, where it becomes further disintegrated.

Healing of a tuberculous sequestrum, even of considerable size, is possible by encapsulation (Fig. 26). Dissection of a necrotic area from the

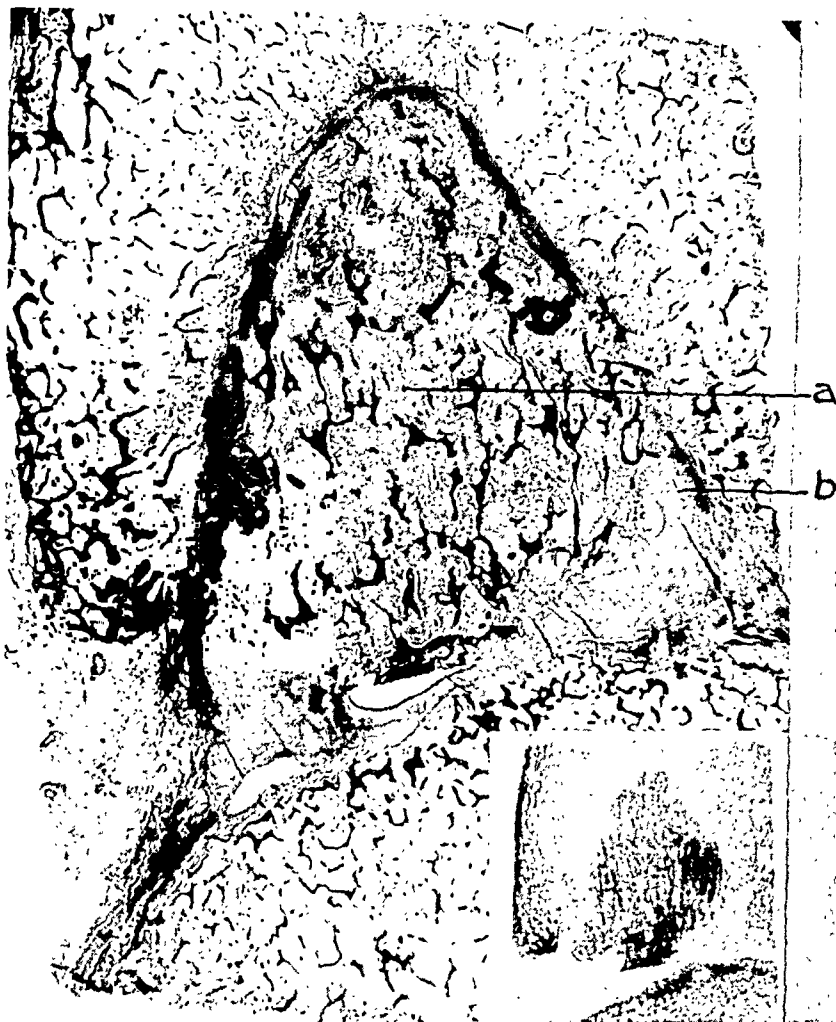


FIG. 26.—A sequestrum *a* of the lower end of the tibia has been partially extruded into the tibio-astragaloid joint. The sequestrum subsequently became encapsulated by a dense fibrous tissue wall *b*, after which all activity within the sequestrum ceased. Again, marked contrast is noted between the sclerotic necrotic bone and the porotic living bone which surrounds it. The inset shows the roentgenologic appearance of this sequestrum.

surrounding tissue may be completed by tuberculous granulations, which undergo fibrous condensation with the formation of a dense capsule. This fibrous wall around the necrotic area buries the focus and prevents further resorption. This phenomenon is well known from studies of tuberculosis in vertebral bodies, where necrotic areas may remain encapsulated throughout life. The lacunar outlines of the trabeculae in the sequestra do not indicate activity, but may be attributed to resorptive changes which occurred in an

earlier period, when the tuberculous granulations were still present. However, if only a few tubercles are present, there is still a possibility of a flare up of the infectious process, augmented by traumatic irritation or lowered general resistance.

SUMMARY.—The subchondral wedge-shaped area of necrosis, resembling a sequestrum is often a diagnostic feature in joint tuberculosis. Unlike the sequestrum in nonspecific osteomyelitis, it need not be dissected free from its surroundings, but may merely represent a subchondral area of necrosis which appears denser in the roentgenogram. The bone infection is usually secondary to an extensive joint involvement; invasion frequently occurs at the joint margins, where the cartilage is thin and the cortex is protected by a delicate synovia only. The advancing zone of infection is demarcated by tuberculous granulations, which may undermine the joint cartilage and even cause it to desquamate in its entire thickness.

Primary bone infection occurred in only 20 per cent of the joints studied microscopically. The infarct type of wedge necrosis of bone, due to vascular occlusion, occurs only rarely. Foci of hypertrophic arthritis, devoid of protective joint cartilage, are often selected as sites of tuberculous invasion contrary to the opinion that hypertrophic arthritis is a protection against tuberculosis.

An area which has undergone tuberculous necrosis becomes inactive as soon as the bone marrow dies. The bony trabeculae therefore remain sclerotic, whereas the surrounding living bone tissue undergoes resorption and becomes porotic. The sequestrum can now become changed only by trauma or molecular disintegration. Trauma may cause portions of the joint end to be broken off. It may then protrude into the joint cavity where it is ground into tiny fragments, or it may be extruded to the exterior if the joint cavity connects with a sinus tract. On the other hand, the sequestrum may become encapsulated in fibrous tissue and remain unchanged indefinitely.

Interpretation of necrotic tissue is difficult, because disintegration makes tissual classification impossible. Often the bony trabeculae furnish the only reliable landmarks, which offer clues as to the preceding course of tissue changes.

The pathologic material was obtained from the private collection of Dr. Ernst Freund, to whom I am indebted for invaluable aid in preparing this paper.

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THE SURGICAL TREATMENT OF HUMAN BITES

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ABOUT three and one-half years ago an investigation of the treatment of human bites was begun at the Beekman Street Hospital, New York City. A search through the records of that institution revealed that the most diverse methods of treatment had been followed, and a discussion of the problem at staff conference brought out that there was not even unanimity of opinion as to just what ought to be done. The writer undertook to investigate the problem and attempt to work out a satisfactory routine treatment which could be followed throughout the hospital.

Any surgeon who has seen some of the results in these cases will appreciate the seriousness of the problem. Apparently the human is the dirtiest of all mouths. In the frankly infected bite there is a foul discharge and a creeping phlegmonous process which frequently extends rapidly up the arm despite the sometimes heroic measures adopted to check it. The organisms involved are usually described as anaerobic streptococci along with spirilla and fusiform bacilli of the Vincent group. The writer has personally seen two deaths from such infections.

Undoubtedly in a fresh case the safest procedure would be actual cauterization or a radical débridement with complete excision of all contaminated tissues. However, these are both formidable procedures and in the hand where most of these injuries occur would involve the sacrifice of important structures. For such procedures hospital admission and extensive local or even general anesthesia would be required. Moreover, permission to perform them would undoubtedly be refused by a considerable number of patients. It was necessary to select some method of treatment that could be applied rapidly by an intern in the emergency room or even, when necessary, on ambulance calls. For many years chemical cauterization has been used for dog bites and as can be judged from our own experience and the reports of others, the results have been good. It was, therefore, determined to use this method in all cases of human bites over a period of time and then attempt to evaluate the efficacy of the treatment.

During the period of 30 months between July 8, 1932, and December 31, 1934, a total of 122 human bites were treated. For the first half of this period all cases were reported immediately to the writer, and all were either seen by him at once or their treatment was directed by him to the house surgeon. An attempt was made to have all cases kept under his personal care during their entire treatment thereafter. All wounds were freely swabbed out with fuming nitric acid on a cotton applicator and immediately flushed with cold water. There is no doubt that this is a

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painful procedure, but the pain is evanescent. Wet dressings were applied in all cases. No wounds were sutured. Since bacillus tetani has never been reported as present in the human mouth and no case of tetanus has, to the best of our knowledge, followed a human bite, no tetanus antitoxin was given. The nitric acid was applied even where joints had been opened and tendons exposed. No anesthesia, local or general, was used. During the latter half of the period in question the writer's routine was applied but he did not personally take charge of all cases. There was no difference in the results in the two groups, and all figures represent the total for the two series.

In the 122 cases cared for in this period bites of all parts of the body were represented but in by far the largest number the fingers and hands were involved. Bites of the fingers were the most frequent—53. Injuries to the hand were only slightly less in number—40 (Table I). This latter group was largely made up of cases in which the injury was not, strictly speaking, a bite, almost all having been produced by striking someone in the mouth and injuring the hand on the teeth. In general the injuries in this group were deep and in many cases the metacarpophalangeal joints were involved, the tooth penetrating directly into the joint. Two of the three poor results in this series belong in this group. Ten bites involved the face and head, and 19 various other parts of the body. The majority occurred in adult males.

TABLE I
DISTRIBUTION OF INJURIES

Total Cases	Fingers	Hands	Faces and Heads	Other Parts
122	53	40	10	19
	43%	33%	8%	16%

For purposes of analysis the entire series of 122 cases may be conveniently divided into three groups. Group one consists of 41 cases in which treatment was carried to completion or nearly so. The time under treatment varied from 2 to 100 days. Excluding the three poor results, from 2 to 31 days, an average of about 12 days. The results in 38 cases were described as "good." By this was meant that no serious infection developed and that the function of the part was not obviously impaired. Scarring was not extensive and was not taken into consideration in evaluating the results. Of the three poor results one was described as "fair," one as "bad," and one as "poor." The first of these cases did not come to the hospital until one month after his injury so we do not feel responsible for this failure and it will be dropped in the statistical summary. One of the metacarpophalangeal joints was involved with an eventual loss of about 50 per cent of the normal motion. The second case was seen five hours after injury and the routine treatment applied. Extensive infection developed and admission to the hospital was necessary. An abscess developed on the dorsum of the hand, which was opened with the actual cautery. Following this procedure which we now believe was unwise, the infection progressed rapidly, and it was necessary to hospitalize him for

30 days. The metacarpophalangeal joint of the index finger was obviously involved and was widely opened. All wounds were finally healed 38 days after the injury. He received physiotherapy for 62 more days but motion in the joint was completely lost. The third case in which the result was noted as "poor" came to the hospital 24 hours after the accident but the first examiner stated that in his opinion the wound was several days old. Involvement of a joint of the finger occurred and this patient was under treatment for 43 days. About 70 per cent of the motion in the joint was permanently lost.

The second group of 63 cases comprises those who made only one visit to the hospital. Of these 48 must be dropped from statistical consideration. For the most part they were from the floating population of New York's lower East Side waterfront and it was found impractical to check on their final results. In the remaining 15 patients we were able to determine the course and the outcome. All can be classed as good results.

The third group comprises 18 cases which were seen more than once but were not in general under treatment long enough to warrant more than an estimate of the result. Of these nine were apparently on the way to recovery. It would be unwise to hazard even a conjecture about the remaining nine.

Our statistical summary must then be built primarily on the 40 cases treated from beginning to healing and on the 15 which were seen only once but in which we were able to find out the end-result. In these two groups there were 55 cases. The results can be called satisfactory in 53 cases or 96 per cent and unsatisfactory in 2 cases or 4 per cent. In addition we have the nine cases which we were fairly sure were on their way to recovery. Adding these we have a total of 64 cases with 62 good results, or 97 per cent and 2 bad results, or 3 per cent (Table II). Considering some of our previous unfortunate experiences with these cases we have been definitely encouraged by these results. We do not regard the problem as solved but we feel that a definite advance has been made in handling this simple but serious type of injury.

TABLE II

SUMMARY OF RESULTS OF TREATMENT

Cases Followed Sufficiently to Know Results	Good Results	Cases Followed Sufficiently to Estimate Results	Good Results	Cases Lost
55 *	53 96%	64 *	62 97%	57

* One case omitted from summary.

We feel that cauterization with nitric acid should be done even in cases of several days' standing. In addition to the one questionable 24 hour case which did badly, several appeared in our series first seen from one to four days after injury. All were cauterized and, with the exception of the one case noted, all did well. We have not found the after effects of the nitric acid burns particularly painful. In the average case the wound drains for

about five or six days, but, and this is important to note, the drainage does not have the foul odor so characteristic of infected human bites. Wet dressings are maintained during this period. By about the sixth day the eschar has dissolved or separated and most of the wounds heal cleanly from the bottom. Most cases are discharged in two weeks or less. The nitric acid eschar rarely seems to cause retention of secretions. This probably occurred in our unsatisfactory cases.

The following instructions are posted in the Emergency Room for the guidance of the intern staff:

(1) All human bites are to be thoroughly wiped out with fuming nitric acid. The acid is to be applied with a cotton wound applicator of a size appropriate to the wound and the cotton is to be saturated but not dripping. If any nitric acid is spilled on the skin the area must be immediately washed with cold water.

(2) Wet dressings are to be applied in all cases and instructions given for hot soaks at home.

(3) All cases of human bites are to be referred to the out-patient department to be seen the following day.

(4) No tetanus antitoxin is to be given.

(5) No wounds of this type are to be sutured.

Cauterization with nitric acid may seem a brutal procedure, but it is only necessary to see one of these creeping infections start up the arm to realize that heroic measures are fully justified if they will prevent such an outcome.

BRIEF COMMUNICATIONS AND CASE REPORTS

HEMANGIOSARCOMA OF THE MEDIASTINUM*

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THE history of the patient herewith presented was detailed in the *ANNALS OF SURGERY*, 85, 615-618, April, 1927, in the Proceedings of the New York Surgical Society for December 8, 1926, when the case was first reported.

Abridged Résumé.—Phyllis H., female, at the age of two years became paraplegic. A diagnosis had been made, at the Hospital for Joint Diseases, by Dr. Alfred W. Pollak, of an enormous mediastinal tumor involving more than two-thirds of the thoracic space, which had eroded the ribs at one point, and was obviously causing the paraplegia from pressure upon the cord.

A small, posterior mediastinotomy was performed April 15, 1924, and a generous piece of the tumor removed for examination, the pathology of which was diagnosed as angiosarcoma by Dr. F. S. Mandlebaum. The wound healed nicely, and treatment with Coley's mixed toxins was immediately begun by Doctor Pollak, beginning with one-twenty-fifth minim. A number of injections were made which caused very severe reactions, but, only three weeks after the operation, the child began to walk, the relief apparently having resulted from the decompression. This improvement continued, and a series of roentgenograms by Dr. H. B. Philips demonstrated the gradual disappearance of the tumor mass, and in October, 1926, a roentgenogram by Doctor Jaches revealed a normal chest. The child has been well ever since.

Doctor Gross, Director of the Laboratory at Mount Sinai Hospital, diagnosed the tumor as a hemangio-endothelioma. Dr. James Ewing stated that it was a "Malignant cellular tumor of embryo type, composed of many blood sinuses, lined by two or more rows of tumor cells. Very delicate stroma." It was his opinion that the tumor was extremely malignant.

The patient is now an apparently normal child of 14 years. Roentgenograms have been made every year, and show no abnormality.

Here, at any rate, is a case in which there is no difference of opinion between the pathologists. From the clinical side it certainly was one which offered an extremely grave prognosis.

Doctor Lilienthal stated that he was one of the few who had persisted in the administration of Coley's toxins in inoperable cases, and also as a prophylactic measure following operation. From an experience with some dozen cases, he felt more and more convinced that in the absence of any

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other form of treatment which even remotely promised results, the toxins should be employed as a matter of course.

DISCUSSION. DR. BRADLEY L. COLEY (New York) thought that Doctor Lilienthal had had an unusually favorable experience with the toxins, his continued interest throughout the years having been rewarded more fully than that of most others who have used toxins in a considerable number of cases. The unfortunate feature of this treatment is the uncertainty of obtaining favorable results. One may employ the toxins in several cases without seeing any improvement, which is especially apparent when one treats a large number of patients. Moreover, the combined use of the toxins with other methods of treatment always leaves open the question, when the patient remains well, as to what was responsible for the favorable result. Was it due to operation, radiation, or toxins?

In general, one hesitates to extol any one method when others, also, are of value, and Doctor Coley said he would be the last to advocate the use of toxins alone where either surgery or radiation, or both, might be helpful. However, in the aggregate, a considerable number of cases in which toxins only have been used, proved by microscopic examination to be malignant, following treatment by toxins the patients have survived an appreciable time, upwards of five or even ten years. The mediastinal case presented by Doctor Lilienthal is one that fulfills those requirements. There was no irradiation. The clinical and microscopic diagnosis leaves no doubt as to the malignancy of the process.

Doctor Coley regretted that Dr. Wm. B. Coley could not be present to show one of the most dramatic cases ever encountered. That patient was treated not by him, but by Drs. S. L. Christian and L. A. Palmer of Staten Island. It is known as the "Marine Hospital Case."¹ The patient had an endothelial myeloma of the tibia. An amputation was performed. There was an obvious recurrence in the amputation stump. The patient then developed numerous metastases in various other locations. He received tremendous doses of toxins, but no irradiation at any time. He is well and was shown last January before the American Academy of Orthopedic Surgeons. He is registered as an endothelial myeloma by the Bone Sarcoma Registry (Reg. No. 1143).

There were a number of recorded cases comparable to that of Doctor Lilienthal, and he believed that this should encourage one to anticipate, at least, an occasional similar result in others, and that we should use the toxins in conjunction with whatever other methods, including irradiation and surgery, are applicable to the individual case.

In May, 1934, Dr. Bowman C. Crowell, Registrar of the Bone Sarcoma Registry of the American College of Surgeons, presented the five year survivals of primary malignant bone tumor cases. At that time there were only nine endothelial myeloma cases that had passed the five year mark, and six of the nine had been given toxins in conjunction with other forms of treatment. There are no cases, microscopically confirmed, in which irradiation alone has produced a five year cure.

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JAUNDICE DUE TO OBSTRUCTION BY AN ABERRANT VESSEL AND ADHESIONS *

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NEW YORK

Case 1.—A single woman, age 26, was admitted to Ward M-4, Bellevue Hospital, Second Surgical Division, October 22, 1933. Since infancy she had been subject to "bilious attacks," and always seemed to have had a very sensitive stomach and digestion.

During the two years before admission, she had experienced intermittent attacks of pain in the right upper quadrant, often associated with jaundice. Although neither the pain nor the jaundice was severe, both were very annoying, and the jaundice was particularly in evidence on several occasions when examined. She had had no chills or fever; no diarrhea or clay colored stools. The findings in a gastro-intestinal and gallbladder roentgenologic series were negative. Duodenal drainage was also negative, in that it failed to yield any B bile.

The patient entered the hospital for operation during a symptom free period. Examination revealed a young woman, normal in every respect. Blood pressure 122/68.

Operation.—October 23, 1933. Under gas-oxygen anesthesia, a right rectus muscle splitting incision was made. The gastrohepatic omentum was very short, puckering up, as it were, the common duct, the portal vein and the hepatic artery therein contained; and also bringing the pylorus and the first portion of the duodenum much closer to the gallbladder and liver than is usual. Furthermore, there was a fibrous band containing an artery which arose or came off of the superior aspect of the first portion of the duodenum. This artery was probably a branch of the gastroduodenal artery. The artery and the fibrous band were wrapped around the anterior, right lateral and posterior aspects of the lower third of the common duct in such a way as to rotate or twist and constrict the duct until the duct, at that point, was not more than one-quarter or one-fifth of its normal diameter.† The common duct was not noticeably thickened.

Procedure.—The peritoneum covering the gastrohepatic omentum was divided transversely and the common duct, hepatic artery and portal vein straightened out considerably, but the common duct remained constricted until the artery and the fibrous band wrapped around it were divided. The duct then returned nearly to its normal diameter and, upon compressing the gallbladder, it emptied easily. Believing that this aberrant vessel and fibrous band caused the intermittent biliary obstruction, nothing further was done and the abdomen was closed without drainage. The postoperative course was entirely uneventful, and when examined January 8, 1936, two years and two months postoperative, there had been no return of her jaundice.

Case 2.—Mrs. H. S., age 47, was admitted to Ward M-5, Bellevue Hospital, Second Surgical Division, July 15, 1935. For more than one year she had suffered occasionally from nausea with regurgitation of bitter material, and chronic constipation, aggravated by coffee and fatty foods. Six months before admission she was confined to bed for one month because of jaundice and pain in the right upper quadrant, which radiated to her right shoulder. During the past month she had vomited several times. One week before admission, the discomfort in the right upper quadrant increased markedly and jaundice appeared.

Physical Examination.—An apparently healthy, though definitely jaundiced, very obese woman. Temperature 100.4° F., pulse 78, respirations 20, blood pressure 120/80. There was moderate tenderness in the right upper quadrant and the urine showed three plus bile.

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† The gallbladder was normal but was three-quarters filled with bile. It would not empty when compressed.

Laboratory Data.—van den Bergh Test—Direct: Delayed; Indirect: Slightly positive. N.P.N. 34. Blood sugar 78. Blood type, Group I. W.B.C. 8,500. Icteric index 5. Urine showed bile three plus. Stools brown.

The gallbladder could not be visualized roentgenologically after administration of the dye, suggesting pathology.

Within 23 days, the patient's jaundice cleared up entirely and she was free of abdominal tenderness and symptoms of every kind. However, in view of the fact that she had been so definitely jaundiced six months before and again at the time of admission, it was thought advisable to explore the common duct.

Operation.—August 7, 1935. Under gas-oxygen anesthesia, a right rectus muscle splitting incision was made. The gallbladder, greatly thickened, contained many faceted stones. The cystic duct was stenosed. The ampulla of the gallbladder was greatly thickened. The common duct was enlarged, thickened and adherent to the ampulla of the gallbladder in such a way that the common duct was bent upon itself, so that there was complete, or practically complete, obstruction of the lumen. There were fairly dense adhesions involving the gallbladder, common duct, gastrohepatic omentum, pyloric end of the stomach, duodenum and the hepatic colon.

Procedure.—All adhesions were separated. The common duct was separated from the ampulla of the gallbladder with considerable difficulty, but this did not correct the angulation in it. The gallbladder was removed. The common duct was opened, thoroughly explored, but no stones found. The bile was muddy. Even after freeing the surrounding adhesions we were unable to straighten out the common duct. A large T tube was passed down through the angulation in order to hold the common duct straight and prevent its bending upon itself. A cigarette drain was placed down to Morrison's pouch and the wound was closed.

The postoperative course was uneventful. The T tube was removed on the nineteenth postoperative day. The patient has reported at intervals, and informs us that she has had no further jaundice or symptoms.

COMMENT.—Two cases are reported. In one there were congenital anomalies including an aberrant vessel, and in the other the jaundice was due to adhesions obstructing the duct.

The first case was unusual in that the obstruction was due to the anatomic variation, there being a shortened gastrohepatic omentum and an anomaly of the blood vessels with a band of tissue similar to other bands described as occurring about various portions of the gastro-intestinal tract. The constriction of the common duct was unquestionably the cause of the jaundice, as at the time of operation it was impossible to empty the gallbladder compression before the aberrant vessel was divided. However, after this was severed the gallbladder could be emptied easily.

Dr. William E. Ladd of Boston recently published an article¹ in which he reported 45 cases of "Congenital Obstruction of the Bile Ducts," and divided them into seven groups. The first case herewith presented does not fit into any of these groups, because it demonstrated extrabiliary variations constricting the common duct, whereas Doctor Ladd specifically referred to anatomic variations of the bile ducts.

In the second case, the jaundice was apparently due to an angulation of the common duct with almost complete obstruction. Although jaundice in postoperative cases due to adhesions, scar tissue or other complications, does occur, jaundice caused by the conditions found in this instance is unusual.

Dr. Ellsworth Eliot, Jr.,² has reported three cases similar to this second case, but in his series the obstruction was due to inflammation resulting from a duodenal ulcer.

Either of the cases that have been presented might have had a small stone, mud or sand in the common duct which could have caused jaundice owing to constriction of the common duct, even though so small an amount of mud or a very small stone would not necessarily have caused jaundice in a common duct with a normal lumen.

The intense pain that is commonly a feature of intermittent jaundice due to common duct stone was not a prominent symptom in either of the cases presented. Although diet played no rôle in the first case, the second patient did experience symptoms following the ingestion of certain articles of food, but it must be remembered that she had a definitely diseased gallbladder. Rest in bed afforded the inflammation an opportunity to subside by eliminating the downward pull of the liver on the angulated common duct.

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DISCUSSION.—DR. GUILFORD S. DUDLEY (New York) confessed that personally he had never seen a case with similar, comparable cause of obstruction to the common bile duct, and found it a little difficult to understand why the patient should have had recurring attacks of pain, without progressive jaundice, if the obstruction to the common duct had been due to an abnormal anatomic band. A calculus in the common duct could have been the cause of jaundice, in either patient.

Calculi in the gallbladder may cause no symptoms, and there may also be "silent calculi" in the common duct. A case in point, operated upon January 7, 1936, by the speaker, was cited. The patient gave no history of jaundice, but not only was there a calculus in the gallbladder, but in the common duct as well, which, although apparently normal on inspection, revealed two small calculi on palpation, and when opened it was found to contain five small calculi. There may even have been more that were not detected.

He cited another case with a history of having been operated upon in 1918, a cholecystectomy having been performed. In 1919 she was again operated upon for recurrence of symptoms due to common duct stones, which were said to have been removed at this time. She remained symptom free until 1927, when she had an attack of jaundice which subsided spontaneously. There were no further symptoms until 1932, when she suffered a series of attacks of pain associated with jaundice. Her icteric index was 9. She was operated upon with a diagnosis of common duct stone. Doctor Dudley presented the stone found in her common duct, calling attention to the very interesting fact that the branching of the stone represented the two hepatic ducts. Since the last operation, January, 1933, the patient has remained well.

DR. JOSHUA E. SWEET (New York) interpreted the obstruction of the duct from an aberrant vessel as an unusual instance of what is a normal process in the development of the gallbladder and its ducts. The cystic artery grows out and adheres to the gallbladder at an early stage, before the gallbladder and ducts have reached their final development. When the gallbladder

and ducts develop, there is no room for the duct to develop in a straight line, and thus it is drawn into an S-shaped kink. An accentuation of this process apparently developed in Doctor Patterson's first case.

The second case presented by Doctor Patterson, he thought, represented a situation much more common than suspected. The patient had had an attack six months before she was examined, and had been in bed for one month at that time. That attack probably represented an attempt by the gallbladder to extrude stones, during which attempt the gallbladder very commonly becomes adherent to adjacent viscera, most frequently to some portion of the intestine. As a rule, the stones pass and the adhesions usually separate. But sometimes they do not. This would explain why this woman was fairly comfortable when lying down, *i.e.*, when in the position in which the adhesions had formed, but experienced more difficulty in an erect posture.

Referring to the stone shown by Doctor Dudley, he thought that common duct stones of that type, that is, those which occur in the common duct when there are no stones found in the gallbladder, are very characteristic in their color and also in the fact that, on drying, they fracture by radial cracks and disintegrate completely. The portion of the stone missing in the specimen shown was broken off from a branch which apparently had extended into the stump of the cystic duct. This missing portion Doctor Sweet had left unvarnished in order to see whether it belonged in this category, and it did disintegrate. The larger portion was varnished for preservation. These stones occur frequently in the Chinese, and he surmised that they were the result of a mixture of pancreatic juice and bile in the common duct. He also emphasized that these cases demonstrate a fact, well understood, but often forgotten; namely, that jaundice is a symptom of common duct pathology and has no relation whatever to gallbladder disease.

THE TREATMENT OF INFECTIONS OF THE FACE BY PROPHYLACTIC VENOUS OBSTRUCTION

CLYDE A. ROEDER, M.D.

OMAHA, NEB.

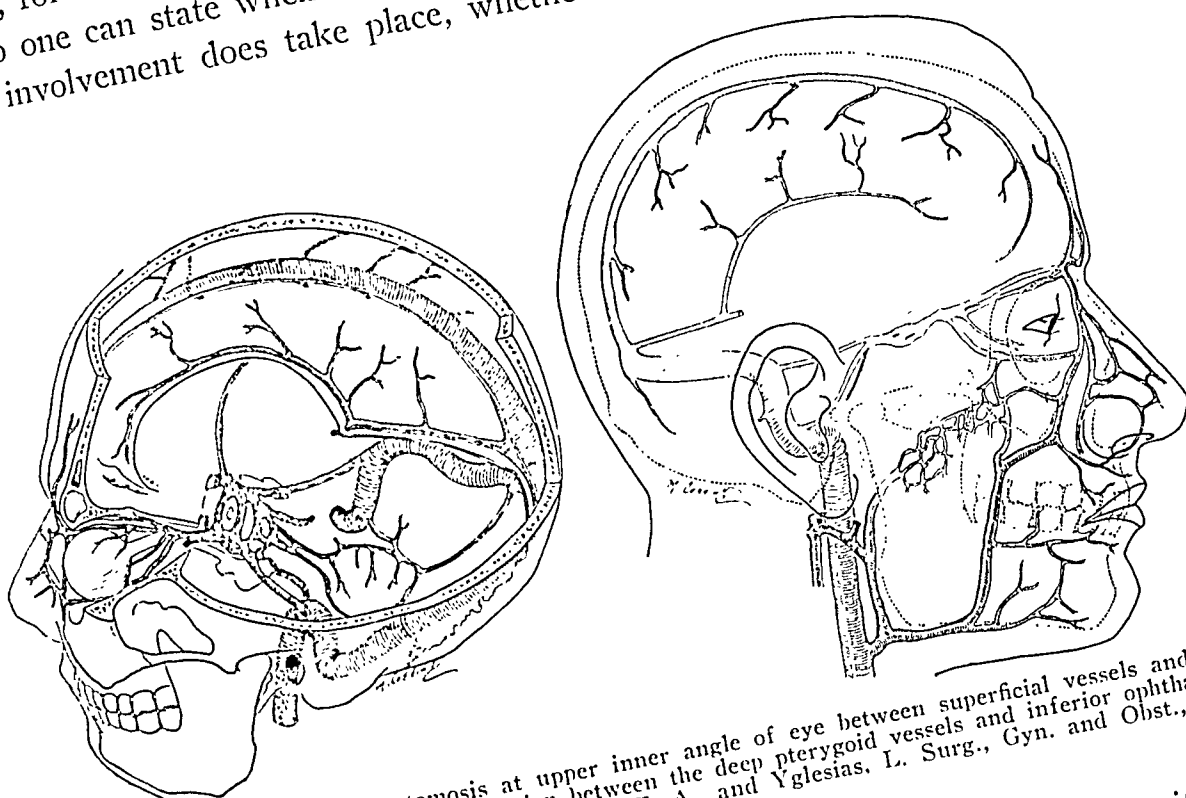
INFECTIONS of the upper lip, cheeks, lateral surfaces of the nose and forehead are so frequently followed by involvement of the adjacent veins and an extension into the cavernous sinus, that the original lesion cannot be given too much consideration. This central portion of the face is drained by a most interesting circle of venous blood, which, in sequence, and starting from the upper lip, consists of the upper facial vein, the angular, the transorbitals (superior and inferior ophthalmics), the cavernous sinus, the vein connecting the lower transorbital (inferior ophthalmic) with the pterygoid plexus, the pterygoid plexus, and the venous connection between the pterygoid plexus and the facial vein. This is very well illustrated by Figures 1 and 2.⁶

These venous channels are evidently without valves, and the blood may flow in either direction; depending upon an obstruction or greater pressure existing in the internal or external portion of the circle. If the internal portion in the region of the pterygoid plexus were obstructed, the blood would flow from the cavernous sinus toward the heart through the transorbital,

INFECTIONS OF THE FACE AFTER SEPTI

angular, and facial veins. If the obstruction existed in the orbital or facial (external) portion of this venous circle, the blood from the cavernous sinus would flow toward the heart through the pterygoid plexus. The physics of these two obstructions should be kept in mind, particularly when confronted by a possible invasion of the facial veins from infection of the upper lip, cheeks, forehead, or lateral surface of the nose.

No one can state when these venous channels will become involved; nor after involvement does take place, whether or not the cavernous sinus will



FIGS. 1 and 2.—Note anastomosis at upper inner angle of eye between superficial vessels and the superior ophthalmic vein, and the connection between the deep pterygoid vessels and inferior ophthalmic vein. None of these veins have valves. (Coller, F. A., and Yglesias, L. Surg., Gyn. and Obst., 277, February 15, 1935.)

become infected. Since it is well known that septic cavernous sinusitis is a fatal complication, any method for its possible prevention is worthy of consideration. Prophylactic ligations of the angular veins have been practiced 1,2,3,4,5,6 with not unfavorable results. We are all aware, I feel sure, that recovery may occur without a ligation of the angular vein. But a more serious question arises in those cases which developed a cavernous sinusitis, *i.e.*, would this fatal complication have occurred if the angular and transorbital veins had been artificially obstructed early in the course of the infection? Transmission of an infection to the cavernous sinus through the pterygoid plexus is a possibility, but more remote than through the angular vein, particularly when the latter is obstructed and the blood pressure in the former is thereby increased. Venous obstruction is worthy of consideration if it can be applied prophylactically, and particularly with no risk, no deformity, and very little discomfort to the patient. With this portion of the above described venous circle artificially obstructed, an infection through the angular and transorbital veins is prevented and coincidentally there results an increase in the venous pressure in the pterygoid plexus. A septicemia

may result with or without any form of venous obstruction, but a cavernous sinusitis may be prevented by external prophylactic venous obstruction.

In 1931 I constructed an apparatus (Fig. 3) which any physician or surgeon can apply during the early stages of infections of the upper lip and adjacent regions. The advantage of this apparatus over ligation of the angular vein is that no operation is necessary to obstruct this vein, and that it also obstructs one of the transorbital or inferior ophthalmic veins which may transmit septic emboli even after the angular vein has been ligated.

It was used once on a patient in December, 1931, and was worn with no discomfort and with a successful outcome. During the surgical drainage

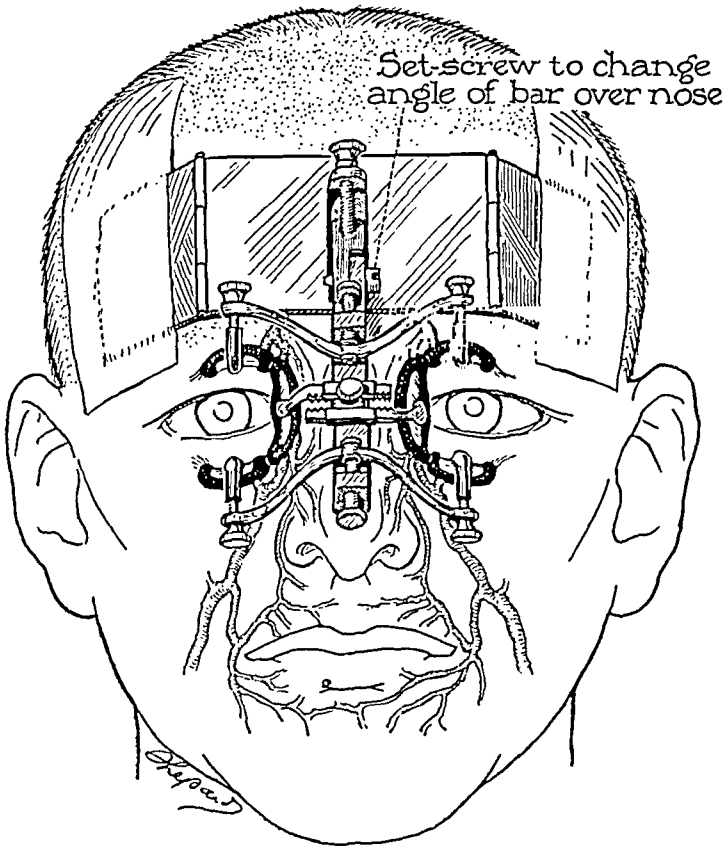


FIG. 3.—Apparatus in place. Note that all veins entering orbit are obstructed. The head band might be longer and lined with sponge rubber in order to increase immobilization by a firmer bandage without much pressure discomfort.

of the upper lip, it was left in place in order to block emboli from extending upward. How long to leave this apparatus in situ after infections of the face have originated I do not know; but certainly if it is to be used, it cannot be applied too soon.

It is offered merely as a simple method of obstructing the angular and transorbital veins during deep and suspiciously dangerous infections of the face, adjacent to the above described veins. The apparatus should be further refined, particularly as to its immobility. An adjustable band completely encircling the head might be an improvement. The venous compression plates and the bar over the nose are lined with sponge rubber, and during their

application the patient's eyelids should be tightly closed. I am well aware of the fact that my one case offers nothing more than a suggestion, and that the subject is still open for discussion as to whether or not early venous obstruction is a worth while procedure in addition to the more essential and proper treatment, operative or nonoperative, of the primary lesion.

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GUMMATOUS INFILTRATION IN MUSCLE

REPORT OF TWO CASES

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CHICAGO, ILL.

THE two cases of gummata occurring in muscle, reported herewith, came under our observation at Cook County Hospital within several weeks. The possibility of diagnostic error and the paucity of reported cases prompted this presentation.

Kaufmann¹ states that syphilis of muscle occurs in two forms; one, a chronic cicatrizing thickening of muscle connective tissue, which leads to atrophy of muscle parenchyma (syphilitic fibrous myositis) and usually involves the biceps and occasionally the masseter muscles, and often leads to contractions. The second type occurs in the form of a gumma which spreads into the neighborhood of muscle, and appears as a protruding, immobile tumor with a tendency to destruction. Adami and Nicholls² state that these tumors must be differentiated from sarcoma. Jordan et al.³ describe eight cases of gummatous infiltration into muscle, and Milch and Galland⁴ report five instances, terming them pseudoneoplastic leucic granulomata, and stress the difficulty of differentiating these tumors from malignant growths.

Case 1.—H. K., white male, 54 years old, was admitted to the outpatient department of Cook County Hospital, complaining of pain in the left forearm, with radiation to the shoulder and wrist. Prior to admission he had been treated at another clinic where sedatives and local hot fomentations were advised. The mass, according to the patient, started spontaneously six weeks prior to admission as a small lump in the center of the forearm and gradually progressed until it involved almost the entire length of the forearm. No previous history of illness was disclosed, and the patient

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emphatically denied syphilis or gonorrhea. In an automobile accident 14 years ago, the patient's left wrist was injured, but he recovered without disability.

The patient has four children living and well. He is a moderate diabetic, controlled on a diet of C-160, P-86, and F-84. Insulin therapy, in the quantity of 20-10-10 units, has been necessary.

On physical examination the heart and lungs were negative. The pupils reacted sluggishly to light and accommodation. There were no pathologic reflexes. Adenopathy was moderate. On the anteromedial aspect of the left forearm was a firm, nodular mass involving the area of the belly of the flexor carpi ulnaris muscle. There was no impairment of muscle function. The tumor was tender to touch, and was adherent for about three-quarters of its length to the skin surface. The patient was reported



FIG. 1.—(Case 1) H. K. Photomicrograph showing an area of necrosis which is surrounded by an area of granulation tissue with many giant cells. Hemalin-eosin ($\times 170$).

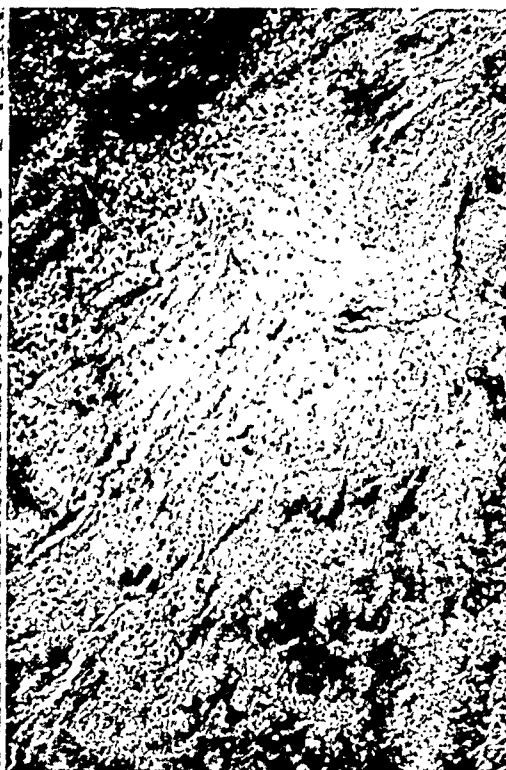


FIG. 2.—(Case 1) H. K. Photomicrograph showing an area of necrosis in which bundles of collagenous tissue can still be recognized. At the periphery there is dense connective tissue which is infiltrated by lymphocytes. Van-Gieson ($\times 150$).

serologically negative. Roentgenograms of the long bones of the forearm were negative. The age of the patient, the loss of weight, the knobby, adherent character of the tumor and the rapidity of growth suggested a tentative diagnosis of fibrosarcoma of muscle.

Exploratory operation was performed September 29, 1935. Through an elliptical incision the mass was removed in toto, together with the involved skin. The superficial portion of the belly of the flexor carpi ulnaris muscle was sacrificed with the mass, and the deeper, normal appearing portion of the muscle belly was electrocoagulated. A more radical operative procedure was not attempted because the exact nature of the mass could not be ascertained macroscopically, and immediate sections were not available. The wound was closed without tension and two rubber tube drains were inserted, one in either end. These were removed at the end of 24 hours. The wound healed by primary union, except in one small area, which closed at the end of four weeks. The pathologist, Dr. J. Kirschbaum, reported "a specimen containing skin 12.5 by 2 cm., beneath which is a mass 14 by 3.5 by 1.5 cm., and on sectioning is yellow-

GUMMA IN MUSCLE

tan color and attached to it is a piece of muscle. The tumor shows extensive areas of caseation necrosis and marked perivascular round cell infiltration. The muscle bundles are separated in places by an intercellular accumulation of plasma cells, round cells and single multinucleated giant cells. The histologic picture is that of a gumma" (Figs. 1 and 2). A blood Wassermann later revealed a four plus reaction, and the patient was placed on antiluetic treatment. No impairment of function was noticed at the end of four weeks.

Case 2.—W. A., a colored laborer, 29 years of age, was admitted to the orthopedic outpatient department of Cook County Hospital with the complaint of swelling of the neck of six weeks' duration, associated with pain and local tenderness which had been preceded by a coryza. A feeling of stiffness was present and a gradual en-

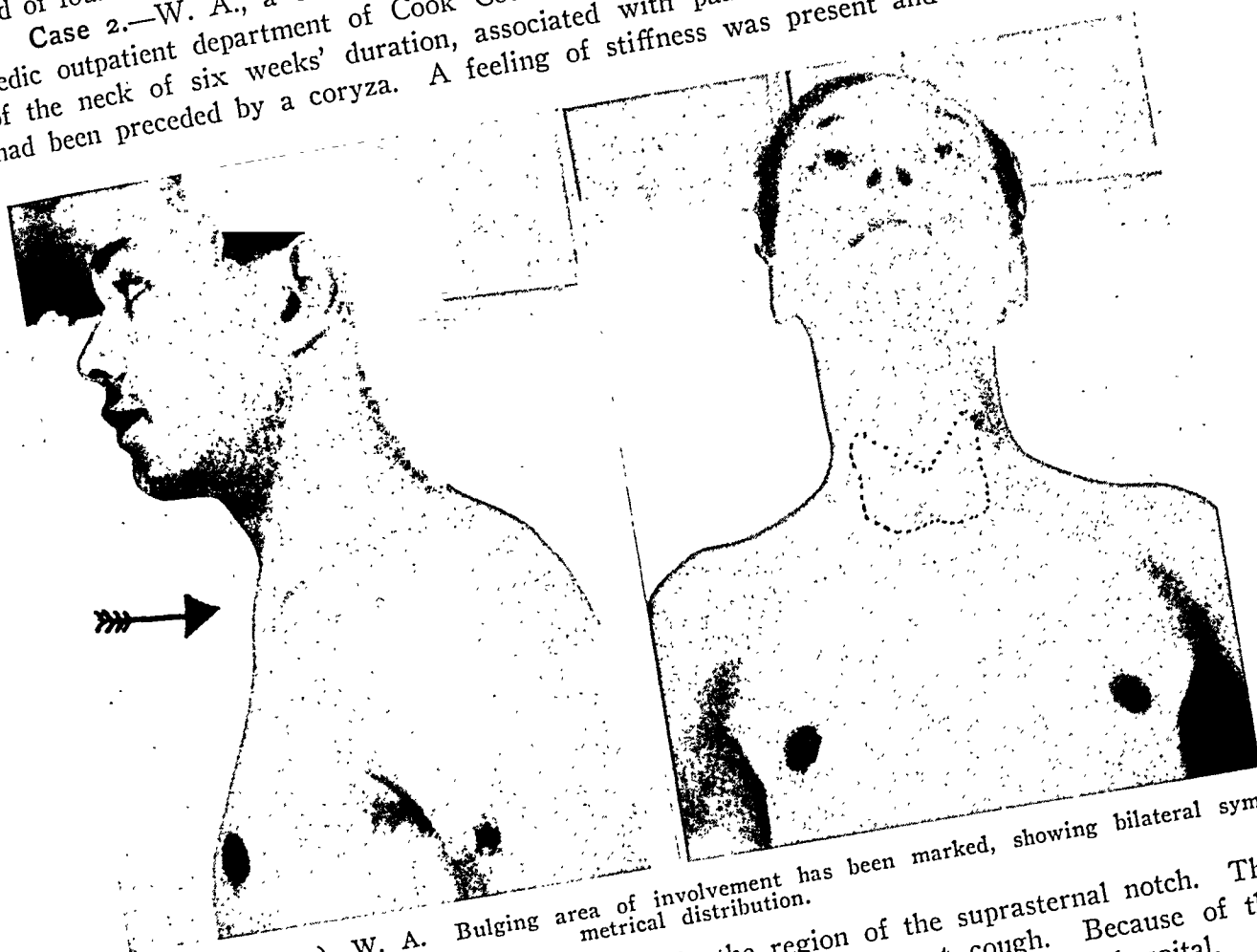


FIG. 3.—(Case 2) W. A. Bulging area of involvement has been marked, showing bilateral symmetrical distribution.

largement of the lower part of the neck in the region of the suprasternal notch. The patient had a tickling sensation in his throat but could not cough. Because of the possibility of a granulomatous or malignant tumor he was admitted to the hospital.

Physical examination revealed a bilateral, symmetrical walnut sized swelling in the region of the distal ends of the sternocleidomastoid muscles. There was definite tenderness in this area, and the patient complained of pain on pressure (Fig. 3).

The heart and lungs were negative, and the pupils reacted sluggishly to light and accommodation. The blood Wassermann was reported two plus. Roentgenograms of the involved area were negative. A course of antiluetic treatment consisting of mercury inunctions and potassium iodide was given. One week later the blood Wassermann was negative and the mass was gradually becoming smaller and the tenderness had diminished.

Stimulated by the findings in Case 1, a biopsy was performed and Dr. Kirschbaum gave the following histologic report: "The tissue taken from the sternocleidomastoid muscle shows an extensive necrosis. The smaller sized arteries are thick walled and infiltrated with polymorphonuclear leukocytes. The lumen is frequently obliterated by an organized thrombus. Scattered about are single degenerated muscle fibers with indistinct striations. The histologic picture is that of a gumma."

Dr. L. E. Anderson⁵ states that "gummatous infiltration into muscle is a great rarity, but there is nothing distinctive about the process except the extraordinary deforming scar which it may produce."

CONCLUSIONS

- (1) Gummatous tumefactions of muscle are uncommon.
- (2) These gummata are frequently mistaken for sarcomata.
- (3) Wassermann and Kahn tests and a therapeutic test of mercury and iodides should be tried for all suspicious muscle tumors.
- (4) They respond well to antiluetic treatment.

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THE AMERICAN BOARD OF INTERNAL MEDICINE (INC.)

THE American Board of Internal Medicine, incorporated February 28, 1936, completed its organization on June 15, 1936. The officers chosen were Walter L. Bierring, M.D., Des Moines, Chairman; Jonathan C. Meakins, M.D., Montreal, Vice-Chairman; and O. H. Perry Pepper, M.D., Philadelphia, Secretary-Treasurer. These officers with the following six members constitute the present membership of the board: David P. Barr, M.D., St. Louis; Reginald Fitz, M.D., Boston; Ernest E. Irons, M.D., Chicago; William S. Middleton, M.D., Madison; John H. Musser, M.D., New Orleans, and G. Gill Richards, M.D., Salt Lake City.

The term of office of each member will be three years, and no member can serve more than two consecutive three-year terms.

The organization of the Board is the result of effective effort on the part of the American College of Physicians in conjunction with the Section on Practice of Medicine of the American Medical Association, and these two organizations are represented in the membership of the Board on a five to four ratio respectively.

The American Board of Internal Medicine had previously received the official approval of the two bodies fostering its organization, as well as that of the Advisory Board for Medical Specialties and the Council on Medical Education and Hospitals of the American Medical Association.

The purpose of the Board will be the certification of specialists in the field of internal medicine, and the establishment of qualifications with the required examination procedure for such certification.

While the Board is at present chiefly concerned with the qualification and procedure for certification in the general field of internal medicine, it is intended to inaugurate immediately after July 1, 1937, similar qualification and procedure for additional certifica-

tion in certain of the more restricted and specialized branches of internal medicine, as gastro-enterology, cardiology, metabolic diseases, tuberculosis, allergic diseases, *etc.* Such special certification will be considered only for candidates who have passed at least the written examination required for certification in general internal medicine. The operation of such a plan will require the active participation and cooperation of recognized representatives from each of such special fields of medicine.

Each applicant for admission to the examination in internal medicine will be required to meet the following standards:

General Qualifications

- (1) Satisfactory moral and ethical standing in the profession.
- (2) Membership in the American Medical Association or, by courtesy, membership in such Canadian or other medical societies as are recognized for this purpose by the Council on Medical Education and Hospitals of the American Medical Association. Except as here provided, membership in other societies will not be required.

Professional Standing

- (1) Graduation from a medical school of the United States or Canada recognized by the Council on Medical Education and Hospitals of the American Medical Association.
- (2) Completion of an internship of not less than one year in a hospital approved by the same council.
- (3) In the case of an applicant whose training has been received outside of the United States and Canada, his credentials must be satisfactory to the Advisory Board for Medical Specialties and the Council on Medical Education and Hospitals of the American Medical Association.

Special Training

- (1) Five years must elapse after completion of a year's internship in a hospital approved for intern training before the candidate is eligible for examination.

- (2) Three years of this period must be devoted to special training in internal medicine. This requirement should include a period of at least several months of graduate work under proper supervision in anatomy, physiology, biochemistry, pathology, bacteriology, or pharmacology, particularly as related to the practice of internal medicine.

This work may be carried on in any domestic or foreign medical school or laboratory recognized by the Council on Medical Education and Hospitals of the American Medical Association as offering appropriate facilities for this type of postgraduate experience; or it may include a period of at least several months of graduate work under proper supervision in internal medicine or in its restricted and specialized branches in any domestic or foreign hospital, clinic, or dispensary, recognized by the above Council as offering appropriate facilities for this type of postgraduate experience.

- (3) A period of not less than two years of special practice in the field of internal medicine or in its more restricted and specialized branches.

The American Board of Internal Medicine does not propose to establish fixed rules for the preliminary training of candidates for certification in this field. Broad general principles for training, however, may be outlined, although such suggestions as are made must, of necessity, be subject to constant changes reflecting the dynamic nature of the specialty.

A sound knowledge of physiology, biochemistry, pharmacology, anatomy, bacteriology, and pathology, in so far as they apply to disease, is regarded as essential for continued progress of the individual who practices internal medicine. The more factual knowledge of medicine and its basic sciences is not sufficient. The candidate must have had training in their use in furthering his understanding of clinical medicine. This implies practical experience under the guidance of older men who bring to their clinical problems ripe knowledge and critical judgment. Preparation to meet this requirement adequately may

be even more difficult to obtain than the so called scientific training. It may, however, be acquired in the following ways:

(a) By work in a well organized hospital outdoor clinic conducted by competent physicians.

(b) By a prolonged period of resident hospital appointments likewise directed by skilled physicians.

(c) By a period of training in intimate association with a well trained and critical physician who has taken the trouble to teach and guide his assistant rather than to require him only to carry out the minor drudgery of a busy practice.

(4) The Board does not consider it to the best interests of internal medicine in this country that rigid rules as to where or how the training outlined above is to be obtained. Medical teaching and knowledge are international. The opportunities of all prospective candidates are not the same. Some may have the opportunity of widening their knowledge by a period of study abroad. Others, at the other extreme, may be restricted to a comparatively narrow geographic area and their detailed training must be obtained in short periods scattered over a long time. Although it is laid down that at least five years must elapse between the termination of the first intern year and the time when the candidate is eligible to take the examination, a longer period is advisable. The Board wishes to emphasize that the time and training are but means to the end of acquiring a broadness and depth of knowledge of internal medicine which the candidate must demonstrate to the Board in order to justify it in certifying that he is competent to practice internal medicine as a specialty. The responsibility of acquiring the knowledge as best he may rests with the candidate, while the responsibility of maintaining the standard of knowledge required for certification devolves on the Board.

Method of Examination

The examination required of candidates for certification as specialists in Internal Medicine will comprise Part I (written), and Part II (practical or clinical).

PART I. The written examination is to be held simultaneously in different sections of the United States and Canada and will include:

(a) Questions in applied physiology, physiologic chemistry, pathology, pharmacology, and the cultural aspects of medicine.

(b) Questions in general internal medicine.

The first written examination will be held in December, 1936, and candidates successful in this written test will be eligible for the first practical or clinical examination which will be conducted by members of the Board near the time for the annual session of the American College of Physicians at St. Louis in April, 1937. The second practical examination will be held at Philadelphia near the time of the annual session of the American Medical Association in Atlantic City in June, 1937.

The fee for examination is forty dollars, which must accompany the application, and an additional fee of ten dollars is required when the certificate is issued.

Application blanks and further information can be obtained by addressing the office of the chairman, Walter L. Bierring, M.D., Suite 1210, 406 Sixth Avenue, Des Moines, Iowa, U. S. A.

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